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United States Department of the Interior

FISH AND WILDLIFE SERVICE

Washington Fish and Wildlife Office
510 Desmond Dr. SE, Suite 102
Lacey, Washington 98503

In Reply Refer To:
01EWFW00-2012-F-0046
01EWFW00-2012-F-0109

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OFFICE OF
ENVIRONMENTAL CLEANUP

Daniel Opalski, Director
Office of Environmental Cleanup
U.S. EPA – Region 10
1200 Sixth Avenue, Suite 900, ECL-117
Seattle, Washington 98101

Rick Albright, Director
Office of Air, Waste, and Toxics
U.S. EPA – Region 10
1200 Sixth Avenue, Suite 900, AWT-128
Seattle, Washington 98101

Dear Mr. Opalski and Mr. Albright:

Subject: Biological Opinion – Lower Duwamish Waterway Cleanup Actions at Jorgensen Forge and Boeing Plant 2/Duwamish Sediment Other Area

This document transmits the U.S. Fish and Wildlife Service's Biological Opinion (Opinion) based on our review of the cleanup actions and related activities proposed by the U.S. Environmental Protection Agency (EPA) at two locations within the Lower Duwamish Waterway Superfund Site, and their potential effects on the bull trout (*Salvelinus confluentus*) and designated bull trout critical habitat. This formal consultation has been conducted in accordance with section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*).

The EPA provided information in support of "may affect, likely to adversely affect" determinations for the bull trout and designated bull trout critical habitat:

- Superfund Removal Action at the Jorgensen Forge Facility and Early Action Area 4 – Cover Letter and Biological Assessment (BA), dated November 23, 2011, and received in our office on November 28, 2011 (FWS Ref. No. 01EWFW00-2012-F-0046);

- Boeing Plant 2/Duwamish Sediment Other Area/Southwest Bank Corrective Measure and Habitat Project – Cover Letter and BA, dated January 13, 2012, and received in our office on January 17, 2012 (FWS Ref. No. 01EWFW00-2012-F-0109).

The enclosed Opinion addresses the proposed actions' adverse effects on the bull trout and designated bull trout critical habitat, and includes mandatory terms and conditions intended to minimize certain adverse effects. The EPA has determined that these actions will have "no effect" on several additional listed species and critical habitat known to occur in King County, Washington. There is no requirement for the U.S. Fish and Wildlife Service to concur on "no effect" determinations. Therefore, your determinations that these actions will have no effect on these species and critical habitat rest with the Federal action agency.

If you have any questions regarding the Opinion or your responsibilities under the Endangered Species Act, please contact Ryan McReynolds at (360) 753-6047 or Martha Jensen at (360) 753-9000, of this office.

Sincerely,

Ken S. Berg, Manager
Washington Fish and Wildlife Office

cc:
USEPA, Seattle, WA (H. Arrigoni)
USEPA, Seattle, WA (A. Lambert)

Endangered Species Act - Section 7 Consultation

BIOLOGICAL OPINION

U.S. Fish and Wildlife Service References:
01EWFW00-2012-F-0046
01EWFW00-2012-F-0109

Lower Duwamish Waterway Cleanup Actions
Jorgensen Forge and Boeing Plant 2/
Duwamish Sediment Other Area

King County, Washington

Agency:

U.S. Environmental Protection Agency
Region 10, Seattle, Washington

Consultation Conducted By:

U.S. Fish and Wildlife Service
Washington Fish and Wildlife Office
Lacey, Washington

For Ken S. Berg, Manager
Washington Fish and Wildlife Office

August 22, 2012
Date

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LIST OF ACRONYMS AND ABBREVIATIONS

Act	Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*)
Applicants	Jorgensen Forge Corporation and The Boeing Company
BA	Biological Assessment
BMP	Best Management Practice
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CSL	Cleanup Screening Level
CSO	Combined Sewer Overflow
cy	cubic yards
DSOA	Duwamish Sediment Other Area
EE/CA	Engineering Evaluation/Cost Analysis
EAA	Early Action Area
EPA	U.S. Environmental Protection Agency
FMO	Foraging, Migration, and Overwintering
HQ	Hazard Quotient
LDWG	Lower Duwamish Waterway Group
MLLW	Mean Lower Low Water
NPDES	National Pollutant Discharge Elimination System
NRDA	Natural Resource Damage Assessment
NTU	Nephelometric Turbidity Units
Opinion	Biological Opinion
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyls
PCE	Primary Constituent Elements
RAB	Removal Action Boundary
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RM	river mile
RPM	Reasonable and Prudent Measures
Service	U.S. Fish and Wildlife Service
SEV	Severity of Effect
SPL	sound pressure level
SQS	Sediment Quality Standards
TRV	Toxicity Reference Values
VOC	volatile organic compound
WRIA	Water Resource Inventory Area

CONSULTATION HISTORY

The U.S. Environmental Protection Agency (EPA) and their Applicants propose to conduct coordinated cleanup actions and related activities at two locations within the Lower Duwamish Waterway Superfund Site. These actions include removal of contaminated media from the lower Duwamish and adjacent uplands, replacement with clean back-fill, related source control measures, related habitat enhancement and mitigation measures, and associated activities.

The EPA is the lead Federal action agency, responsible for the approval, administration, and oversight of these cleanup actions and related activities, pursuant to the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Resource Conservation and Recovery Act (RCRA). The Applicants, or Responsible Parties, are the Jorgensen Forge Corporation (Jorgensen Forge) and the Boeing Company (Boeing). The EPA and Responsible Parties have entered into Orders on Consent, have completed an Engineering Evaluation/Cost Analysis (EE/CA), Corrective Measures Study, and selected a preferred alternative for each cleanup action (Table 1).

The EPA has completed a Remedial Investigation (RI) of the larger Superfund Site (Windward Environmental 2010), and has determined that each of the proposed actions is fundamental to, and must proceed in advance of, the comprehensive cleanup and remediation action. These cleanup actions require EPA approval, and the action at Boeing Plant 2 will likely require the issuance of Federal permits under both the Clean Water Act, Section 404, and Rivers and Harbors Act, Section 10. Federal approvals, and issuance of Federal permits, establish a nexus requiring consultation under section 7(a)(2) of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*)(Act).

The U.S. Fish and Wildlife Service (Service) based this Biological Opinion (Opinion) on the following sources of information:

- Superfund Removal Action at the Jorgensen Forge Facility and Early Action Area 4 (EAA-4) – Cover Letter and Biological Assessment (BA), dated November 23, 2011, and received in our office on November 28, 2011 (Anchor QEA 2011a);

- Additional information provided by the EPA, Re: Jorgensen Forge Removal Action (Blocker, in litt. 2012);

- Memorandum - Jorgensen Forge BA Response to Comments (Anchor QEA, in litt. 2012);

- Boeing Plant 2/Duwamish Sediment Other Area (DSOA)/Southwest Bank Corrective Measure and Habitat Project – Cover Letter and BA, dated January 13, 2012, and received in our office on January 17, 2012 (AMEC Geomatrix 2011).

Table 1. Summary - Applicants, orders, and documentation.

Site / Action	Applicant / Responsible Party	Orders on Consent	Documentation
Superfund Removal Action at the Jorgensen Forge Facility EAA 4	Jorgensen Forge Earle M. Jorgensen Company	Settlement Agreement and Order on Consent for Removal Action (June 30, 2003) First Amendment (2008)	EPA Docket No. CERCLA-10-2003-0111 Final EE/CA – March 2011 (Anchor QEA 2011b) Action Memorandum Re: Alternative Selection (EPA 2011)
Boeing Plant 2/ DSOA/ Southwest Bank Corrective Measure and Habitat Project	Boeing	Administrative Order on Consent (1994) Consent Decree with Natural Resource Trustees (2010)	RCRA Docket No. 1092-01-22-3008(h) Alternatives Study (AMEC and FSI 2010)

- A field review of the project site (December 5, 2011); and,
- Various scientific literature and personal communications cited herein.

A complete record of this consultation is on file at the Washington Fish and Wildlife Office in Lacey, Washington.

The following timeline summarizes the history of this consultation:

July 29, 2011 – The Service provided written comments to the EPA and Boeing based on our review of the draft BA (dated May 2011) addressing the Boeing Plant 2/DSOA corrective measure.

October 19, 2011 – The Service met with the EPA and Boeing to discuss the Boeing Plant 2/DSOA corrective measure in advance of consultation.

November 28, 2011 – The Service received a cover letter and BA from the EPA requesting formal consultation on the removal action at the Jorgensen Forge Facility and EAA-4.

December 20, 2011 – The Service requested additional information regarding the Jorgensen Forge removal action.

January 3, 2012 – The EPA provided a partial response to our request for information regarding the Jorgensen Forge removal action (via email correspondence).

January 17, 2012 – The Service received a cover letter and BA from the EPA requesting formal consultation on the Boeing Plant 2/DSOA corrective measure and habitat project.

February 7, 2012 – Jorgensen Forge provided a partial response to our request for information regarding the Jorgensen Forge removal action (via email correspondence, with attachments).

February 7, 2012 – The Service initiated formal consultation.

June 28, 2012 – The Service shared a copy of the draft Opinion with the EPA for their review and comment.

August 9, 2012 – The EPA provided comments for the draft Opinion.

August 14, 2012 – The EPA provided a draft water quality monitoring plan for Boeing Plant 2.

BIOLOGICAL OPINION

DESCRIPTION OF THE PROPOSED ACTION

The EPA and Applicants (Jorgensen Forge and The Boeing Company) propose to conduct coordinated cleanup actions and related activities at two locations within the Lower Duwamish Waterway Superfund Site. Each of the proposed actions is fundamental to, and must proceed in advance of, comprehensive cleanup and remediation of the larger Superfund Site. These actions include removal of contaminated media from the lower Duwamish and adjacent uplands, replacement with clean back-fill, related source control measures, related habitat enhancement and mitigation measures, and associated activities.

The EPA, Washington Department of Ecology (Ecology), Lower Duwamish Waterway Group (LDWG), and other interested parties and stakeholders are implementing a long term strategy to clean and remediate contaminated portions of the lower Duwamish, and control historic and continuing sources of contamination. The EPA placed the Lower Duwamish Waterway onto the National Priorities List of Superfund sites during 2001, but determining the sources of toxic surface water and sediment contamination, and the feasibility of various source control and corrective actions, have been the focus of intensive study since the mid-1970s (LDWG 2012b). Related corrective actions began as early as the 1950s and 60s with curtailment of toxic industrial discharges and improved or replaced sewer and water treatment infrastructure. Corrective actions have continued to the present in the form of hazardous waste disposal programs, preservation and restoration of intertidal habitats, control and retrofit of combined sewer overflows (CSOs) and further improvements to sewer and water treatment infrastructure, and cleanup (removal and disposal) of soil, water, and sediment contamination at a number of locations along the lowermost six miles (LDWG 2012a). The members of the LDWG, including Boeing, the City and Port of Seattle, and King County have entered into a voluntary agreement with the EPA and Ecology to improve and better coordinate investigative and feasibility studies, and to prioritize, strategically plan, and complete corrective actions and cleanups.

The EPA identifies and prioritizes EAAs where they are part of a larger Superfund site and may become a threat to people or the environment before the long term comprehensive cleanup can be completed (EPA 2012c). Cleanup and source control actions, when taken at or within EAAs, also serve the purpose of sequencing actions so as to prevent re-contamination and improve the efficiency and cost effectiveness of comprehensive cleanup and remediation efforts.

The EPA and Responsible Parties have already taken Interim Measures at these EAA sites and facilities, including stormwater system improvements and related source control measures, Time Critical Removal Actions, and "independent" actions (AMEC Geomatrix 2011, Appendix A, pp. 1-2). Also, the EPA and King County completed cleanup at the Duwamish Diagonal EEA during 2005 (EPA 2012c), which was the subject of a previous consultation with the Service (X Ref. 1-3-04-F-0090). Figures 1 and 2 depict the Superfund Site, the location of EAAs, and the vicinity of the proposed actions.

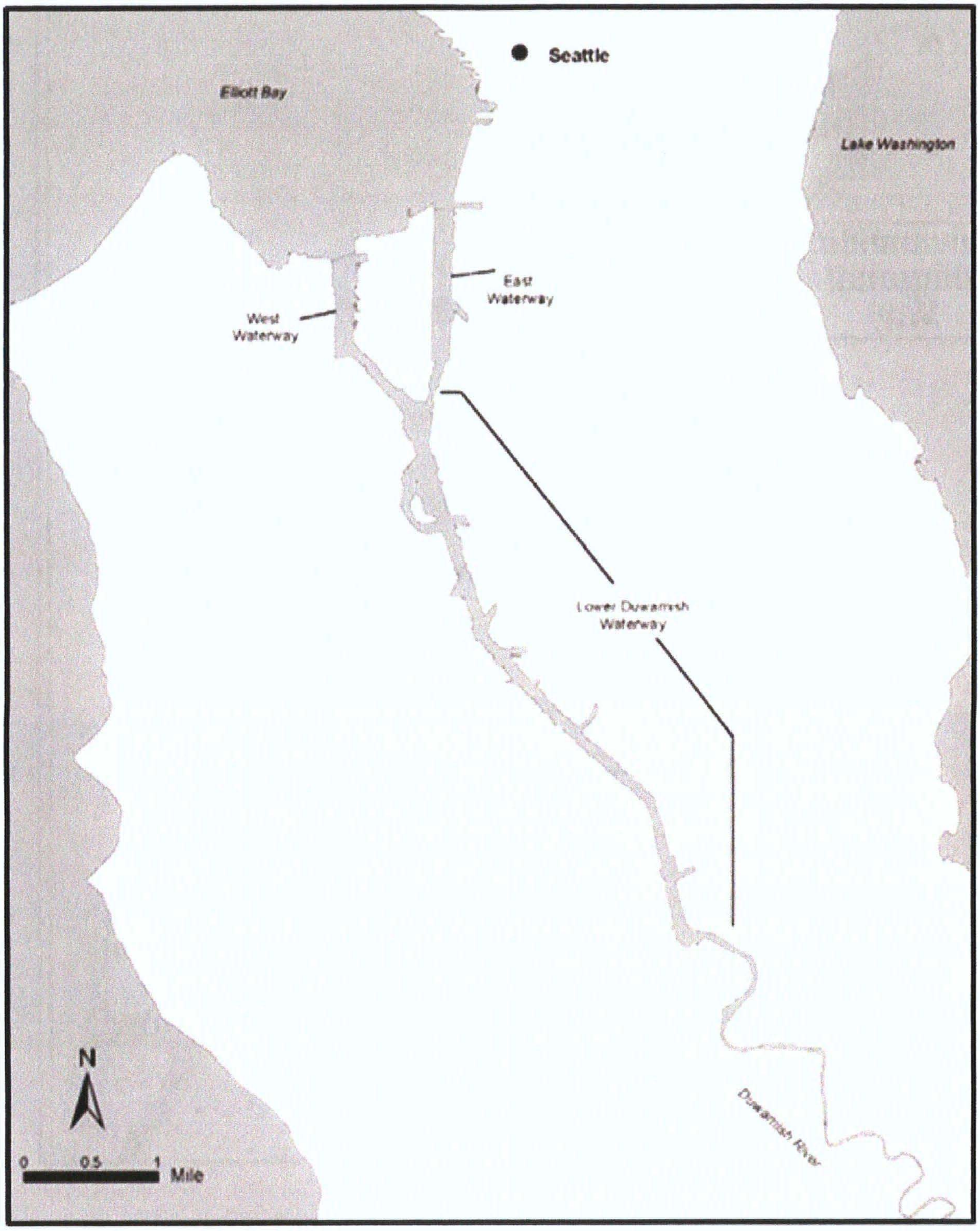

Figure 1. Vicinity map (EPA 2012c).

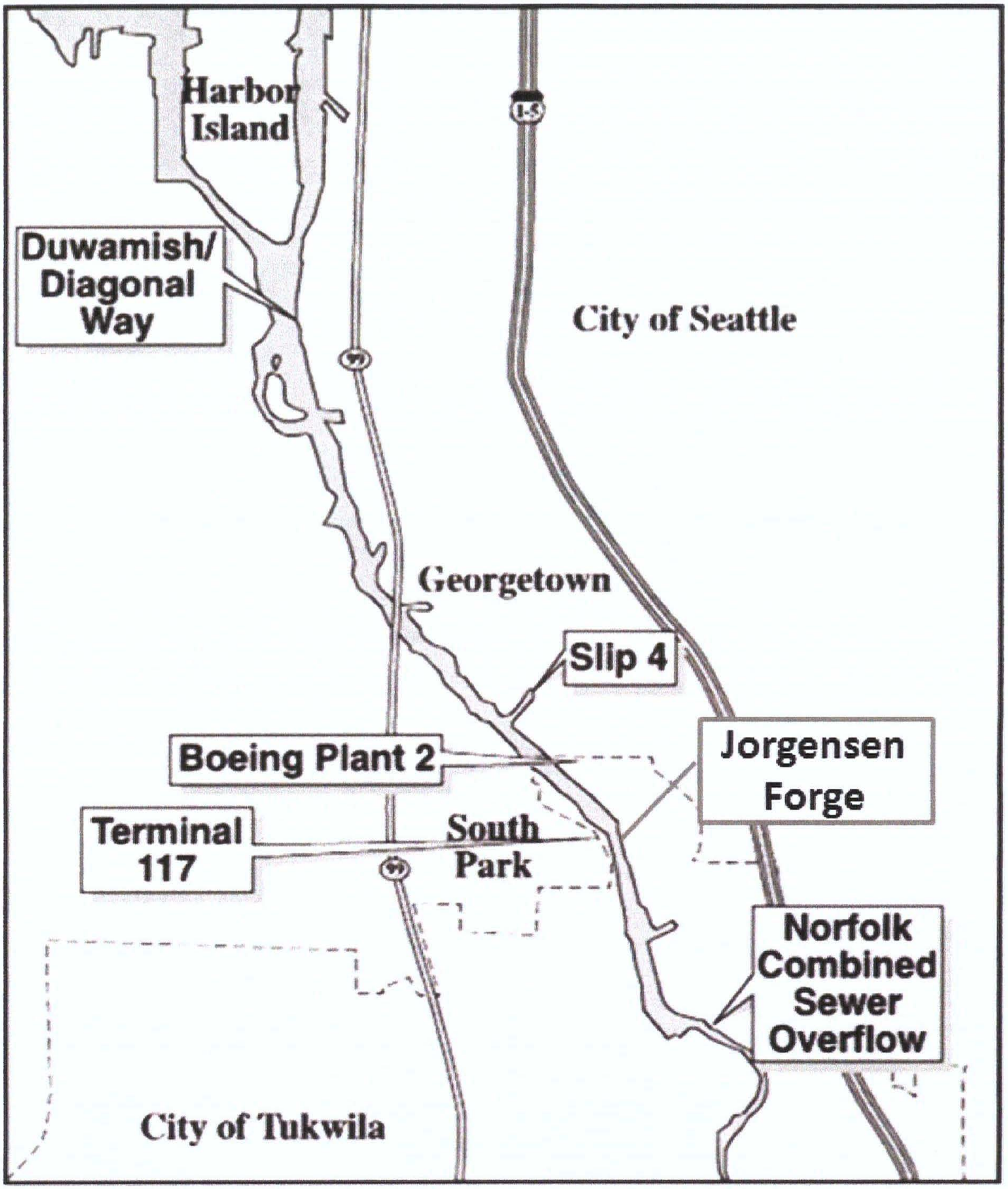

Figure 2. Location of EAAs and proposed actions (EPA 2012c).

The proposed actions include cleanup, source control, habitat enhancement, and associated activities planned for implementation at the Jorgensen Forge Facility and EAA-4, and at the Boeing Plant 2 Facility and DSOA (including the Boeing-owned portions of Slip-4). The actions are located between river mile (RM) 2.8 and 3.6 of the lower Duwamish River, in the Cities of Seattle and Tukwila (King County, Washington): Township 24 North, Range 4 East, Sections 29, 32, and 33; Water Resource Inventory Area (WRIA) 9 – Duwamish-Green.

The EPA and Applicants (Jorgensen Forge and Boeing) have established and agreed to the Removal Action Boundaries (RABs), appropriate Removal Action Levels, and preferred removal action alternative for each of the EAA sites and facilities. The EPA, Ecology, and Applicants determined the appropriate set of Removal Action Levels, contaminant concentrations above which sediment cleanup measures are required, based on the most significant risk drivers for human and ecological health, associated risk-based threshold concentrations, remediation objectives, and feasibility. The RI Report characterizes baseline risks for the Lower Duwamish Waterway Superfund Site, identifies significant risk drivers for human health and ecological receptors, and explains the process and considerations for determining appropriate Removal Action Levels (Windward Environmental 2010, Executive Summary).

The proposed actions would permanently remove, in total, approximately 270,000 cy of contaminated media (sediment and soils) from more than 16.5 acres of the lower Duwamish and adjacent uplands. These actions include related source control measures to prevent re-contamination, and habitat enhancement and mitigation measures to partially offset the environmental and natural resource damages resulting from the historic and continuing releases of hazardous substances to the lower Duwamish. The EPA and Applicants expect that the proposed actions will dramatically improve sediment and water quality conditions in these portions of the lower Duwamish, will reduce long term contaminant exposure risks with both human health and ecological benefits, and contribute substantially to the comprehensive Superfund Site cleanup and remediation effort.

The sub-sections that follow provide additional details regarding activities planned for implementation at the Jorgensen Forge Facility and EAA-4, and at the Boeing Plant 2 Facility and DSOA. The BAs submitted by the EPA provide complete project descriptions, which we incorporate here by reference (AMEC Geomatrix 2011; Anchor QEA 2011a). What follows below is only a summary of the complete project descriptions provided by the BAs and any subsequent correspondence between the Service, EPA, and Applicants. The final sub-section summarizes the conservation measures which are common to each of the proposed actions.

Jorgensen Forge and EAA-4

Based on their Final EE/CA, the EPA and Responsible Party (Jorgensen Forge and Earle M. Jorgensen Company) have agreed to a preferred alternative for CERCLA site cleanup and remediation of the Jorgensen Forge Facility and EAA-4. On October 13, 2011, the EPA selected the full removal alternative for this Non-Time Critical Removal Action (Anchor QEA 2011a, p. 2).

The Jorgensen Forge EAA-4 is located at approximately RM 3.6, extending from the waterway's navigational channel shoreward along the right-bank of the Duwamish River (Figure 3). The

Jorgensen Forge EAA-4 is located directly adjacent to both the Boeing Plant 2 Facility and DSOA. The EPA has identified the limits of the RAB (Figure 4), and has characterized site soil and sediment contamination. The site is contaminated with legacy pollutants, principally polychlorinated biphenyls (PCBs), volatile organic compounds (VOCs, including polycyclic aromatic hydrocarbons, PAHs), and metals. Extending from the top-of-bank, at approximately the +20 Mean Lower Low Water (MLLW) mark, to the navigational channel, surface and subsurface sediments exhibit consistently high PCB contaminant concentrations (Anchor QEA 2011a, pp. 34-38). High organic and metal contaminant concentrations are present at shallower depths, mostly within the nearshore intertidal zone.

At the Jorgensen Forge Facility and EAA-4 the proposed action includes (Anchor QEA 2011a, pp. 6-13, 17):

- Removal of all contaminated media exceeding Removal Action Levels (soils, sediment, and debris) from the RAB;

- Dredge removal of 17,000 to 22,000 cy of contaminated sediments from 11 sediment management units, using an enclosed, environmental clamshell bucket;

- Excavation of approximately 6,000 cy of contaminated media and debris from the intertidal zone, along approximately 605 linear ft of channel (+20 thru +2 MLLW);

- Removal of existing creosote-treated wood piles from the intertidal zone using a vibratory hammer, by direct pulling, cutting at the mudline, or by a combination of these methods;

- Placement of slope containment and backfill materials, approximating pre-project contours, including approximately 900 cy of armor rock and 20,500 cy of clean sand/gravel habitat mix; and,

- Waste and contaminated media handling, storage, treatment, and disposal.

The RAB, where contaminated media would be excavated and dredged, includes approximately 1.5 acres of the Duwamish River's channel bed, intertidal zone, and banks (Figure 4). To the extent practicable, the EPA and Jorgensen Forge will complete work located at elevations above +2 MLLW during low tides, with equipment operating from upland positions (Anchor QEA 2011a, pp. 7, 10, 15, 16, 41).

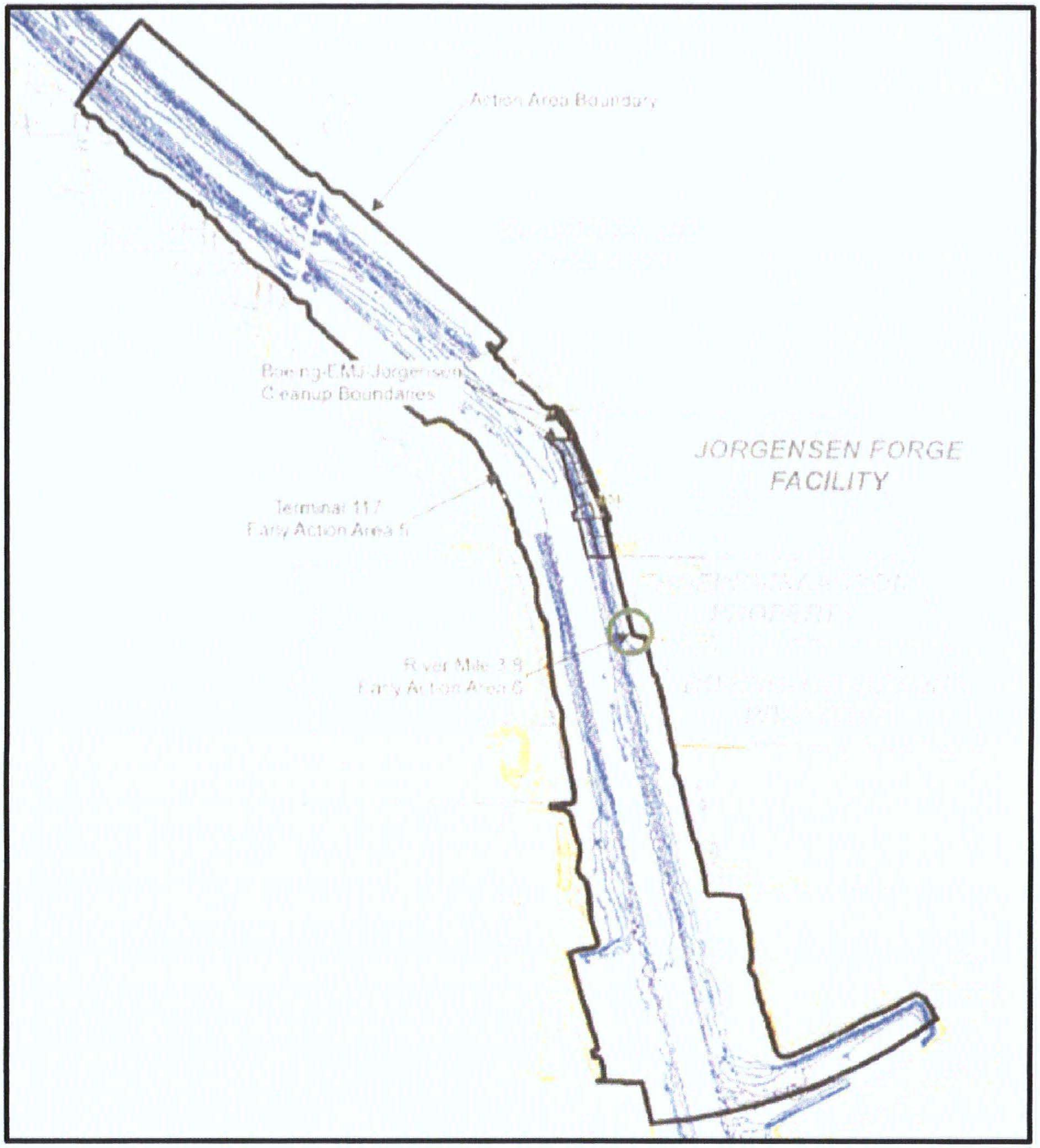

Figure 3. Vicinity Map – Jorgensen Forge EAA-4 (Anchor QEA 2011a).

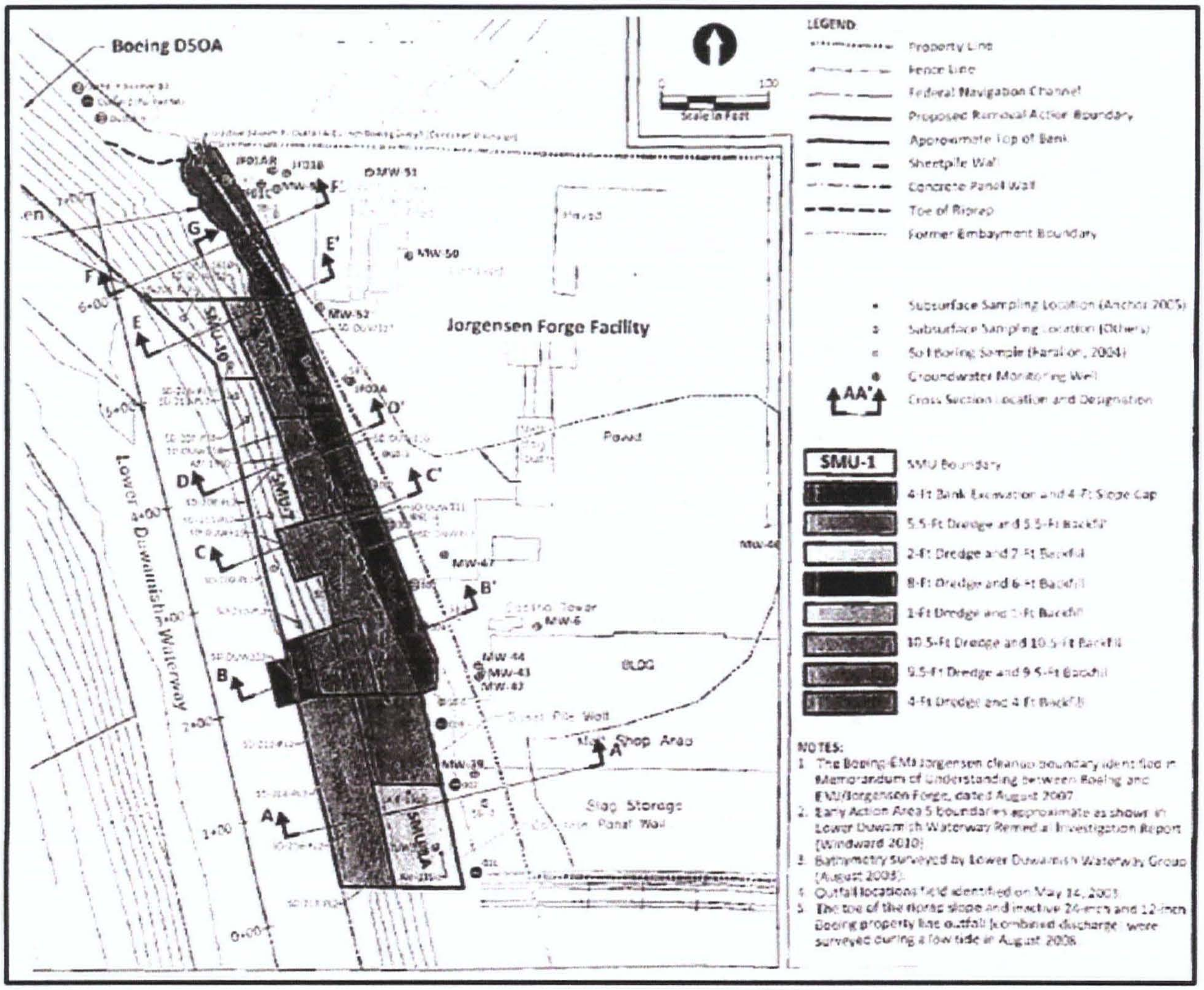

Figure 4. Removal Action Boundary – Jorgensen Forge EAA-4 (Anchor QEA 2011a).

Construction is scheduled to begin during 2013 and will require approximately eight weeks in total. All work below +2 MLLW will be completed between August 1 and February 15, to avoid and minimize impacts to bull trout (*Salvelinus confluentus*) and other listed salmonids (Anchor QEA 2011a, pp. 4, 19). Work located at elevations above +2 MLLW may be completed during low tides at any time of year.

Related source control measures will include cleaning and decommissioning of existing stormwater conveyances and outfalls, abandonment and removal of associated structures and contaminated media, and stormwater system upgrades and improvements, including additional treatment facilities and/or best management practices (BMPs)(Anchor QEA 2011a, p. 18; Anchor QEA, in litt. 2012, pp. 3, 4; Blocker, in litt. 2012; Anchor QEA Memo dated June 19, 2012). Decisions and design details regarding these source control measures are tentative. The EPA and Jorgensen Forge will provide the Service with additional information as related decisions are made and design details become available (Anchor QEA 2011a, p. 18; Anchor QEA, in litt. 2012, pp. 3, 4).

These source control measures include post-construction monitoring and adaptive management, performed in coordination with ongoing monitoring required under the facility's National Pollutant Discharge Elimination System (NPDES) Industrial Stormwater General Permit (Stormwater General Permit). If monitoring identifies discharges exceeding the limits of the Stormwater General Permit, or that are deemed likely to re-contaminate the RAB, the EPA and Jorgensen Forge will identify and implement additional source control measures (Anchor QEA, in litt. 2012, pp. 3, 4).

At the time of this Opinion's writing, related habitat enhancement and mitigation measures are also only tentatively known. CERCLA establishes Natural Resource Damage Assessment (NRDA) procedural requirements designed to evaluate environmental and natural resource damages resulting from historic and continuing releases of hazardous substances, and determine appropriate restoration and public compensation (EPA 2012d). Subject to a pending NRDA settlement between the Responsible Party (Jorgensen Forge and Earle M. Jorgensen Company) and the Elliot Bay Natural Resource Trustees, we expect that Jorgensen Forge will implement habitat enhancement and mitigation measures to offset natural resource damages (Anchor QEA 2011a, p. 18). The EPA is not a party to the NRDA settlement. Jorgensen Forge will provide the Service with additional information as related decisions are made and design details become available.

Boeing Plant 2 and DSOA

The EPA and Responsible Party (Boeing) have agreed to the preferred RCRA corrective measures for contaminant cleanup and source control at the Boeing Plant 2 Facility and DSOA, including the Boeing-owned portions of Slip-4 (AMEC Geomatrix 2011, pp. 3-8). Selection of the preferred alternative was based, in part, upon information included in a corrective measures alternatives study (AMEC and FSI 2010).

The Boeing Plant 2 Facility and DSOA are located between RM 2.8 and RM 3.6, extending from the waterway's navigational channel shoreward along the right-bank of the Duwamish River (Figure 5). The RAB includes portions of Slip-4, which extends north and east of the downstream limits of the DSOA cleanup area (Figure 6). The Boeing Plant 2 Facility and DSOA are located directly adjacent to both the Jorgensen Forge EAA-4.

The EPA has characterized site soil and sediment contamination. The site is contaminated with legacy pollutants, principally PCBs, VOCs (including PAHs and phthalates), and metals. Extending from the bank to the navigational channel, surface and subsurface sediments exhibit consistently high PCB contaminant concentrations (AMEC Geomatrix 2011, pp. 32-33). High organic contaminant concentrations are present with a less consistent distribution, and metal contaminant concentrations are present at shallower depths, mostly within the nearshore intertidal zone at the upstream limits of the cleanup area ("Southwest Bank Shoreline Area", Figure 6). Available information indicates that high metal and organic contaminant concentrations are always co-located with the broader and more extensive PCB contamination (AMEC Geomatrix 2011, pp. 32-33).

Figure 5. Vicinity Map – Boeing Plant 2 and DSOA (AMEC Geomatrix 2011).

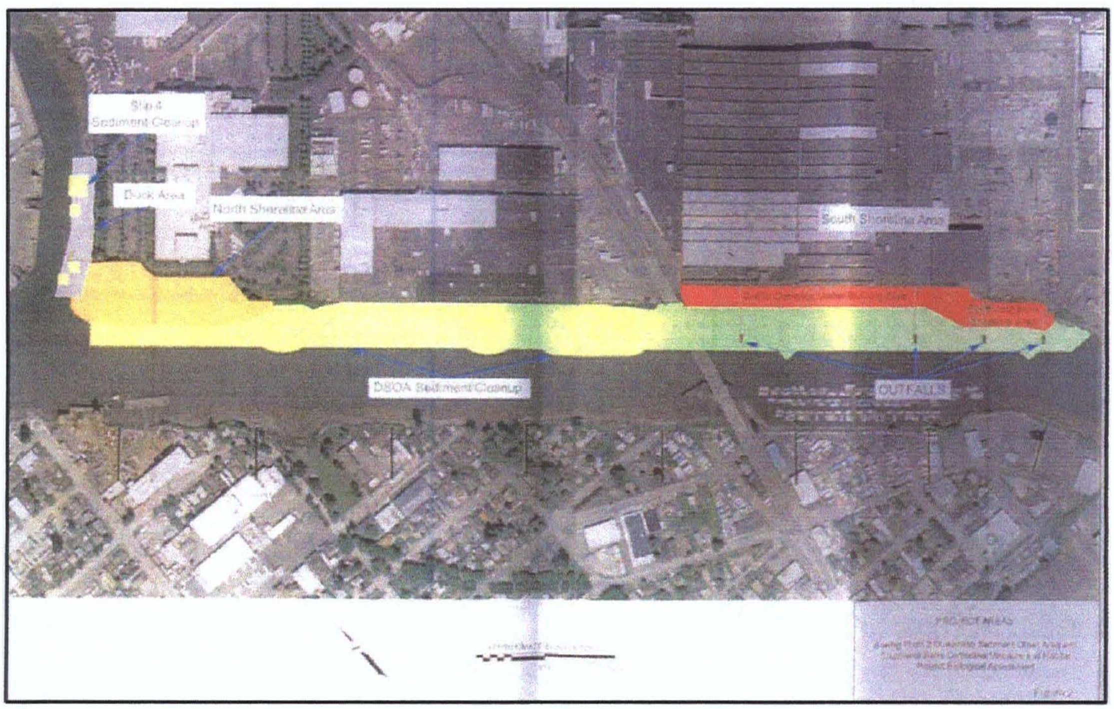

Figure 6. Removal Action Boundary – Boeing Plant 2 and DSOA (AMEC Geomatrix 2011).

At the Boeing Plant 2 Facility and DSOA the proposed action includes (AMEC Geomatrix 2011, pp. 3-8):

- Removal of all contaminated media exceeding Sediment Quality Standards (soils, sediment, and debris) from the RAB;
- Dredge removal of approximately 200,000 cy of contaminated sediments from within the DSOA boundary, using an enclosed, environmental clamshell bucket;
- Dredge removal and excavation of approximately 2,500 cy of contaminated sediments from 4 locations along Slip-4;
- Dredge removal and excavation of approximately 39,000 cy of contaminated soil, sediments, and debris from the "South Shoreline Area" (Figure 6);
- Controlled demolition and removal of the existing overwater structures and bulkheads associated with the Boeing 2-40s Complex (Figure 6), including creosote-treated wood piles and pile clusters, batter boards, concrete foundations and debris, concrete floor slabs, and associated infrastructure;
- Placement of approximately 170,000 cy of clean back-fill within the DSOA boundary, approximating pre-project contours;
- Placement of approximately 2,500 cy of clean back-fill at 4 locations along Slip-4, approximating pre-project contours;
- Placement of approximately 26,000 cy of back-fill along the "South Shoreline Area," including armor and a clean habitat mix suitable for wetland establishment;
- Waste and contaminated media handling, storage, treatment, and disposal; and,
- Habitat enhancement and mitigation components restoring and enhancing approximately 4.8 acres of nearshore intertidal, wetland, and riparian habitat, including approximately 3,000 linear ft of shoreline restoration.

Removal of existing creosote-treated wood piles and pile clusters will be accomplished with the use of a vibratory hammer, by direct pulling, cutting at the mudline, or by a combination of these methods. Where essential to maintaining the structural integrity of adjacent fill, pile clusters may be cut at the excavation surface or at least three feet below the final backfill surface (AMEC Geomatrix 2011, pp. 6, 9).

To the fullest extent practicable, the EPA and Boeing will use an enclosed, environmental clamshell bucket when dredging, to minimize re-suspension of contaminated sediments (AMEC Geomatrix 2011, p. 11). The EPA and Boeing will use a conventional clamshell bucket or grapple when/where coarse debris, dense sediment, or other obstructions prevent use of an enclosed, environmental clamshell bucket. The EPA and Boeing may use a diver-operated hydraulic dredge in the vicinity of the South Park Bridge (AMEC Geomatrix 2011, pp. 11, 13).

Completion of the proposed work will require temporary structures placed on the channel bed, intertidal zone, and banks, including mooring piles or dolphins and an access pier or dock located along Slip-4 (AMEC Geomatrix 2011, pp. 7, 8). The EPA and Boeing expect that temporary moorage for barges and tugs will be needed at approximately twenty locations, and that each of these temporary structures will consist of either a single 12- to 24-inch diameter steel pile, or a cluster of three such piles (i.e., a dolphin). In addition, staging of equipment, materials, and personnel from the uplands will require a temporary access pier or dock located along Slip-4. The pier and ramp will be held in-place with approximately 16, 12-inch diameter steel piles.

The RAB, where contaminated media would be excavated and dredged, includes approximately 15 acres of the channel bed, intertidal zone, and banks (AMEC Geomatrix 2011, p. 41, Figure 6). To the extent practicable, the EPA and Boeing will complete work located at elevations above +2 MLLW during low tides, with equipment operating from upland positions (AMEC Geomatrix 2011, pp. 9, 12, 13).

Construction is scheduled to begin during 2012 and will require two or more years to complete (AMEC Geomatrix 2011, p. 15). All work below +2 MLLW will be completed between August 1 and February 15, to avoid and minimize impacts to bull trout and other listed salmonids (AMEC Geomatrix 2011, pp. 9, 15). Work located at elevations above +2 MLLW may be completed during low tides at any time of year.

Related source control measures already completed by Boeing (i.e., Interim Measures) have included cleaning and decommissioning of existing stormwater conveyances and outfalls, abandonment and removal of associated structures and contaminated media, and removal of caulk and other building materials containing contaminants of concern (AMEC Geomatrix 2011, Appendix A). Additional, future source control measures will include decommissioning all of the existing stormwater outfalls within the project area south of Building 2-10, construction of four new stormwater outfalls, and of three new stormwater treatment facilities (bioswales or functionally-equivalent BMPs) serving approximately 78 acres of impervious surface within redeveloped portions of the Boeing Plant 2 Facility (AMEC Geomatrix 2011, p. 8, Appendix A).

These source control measures include post-construction monitoring and adaptive management, performed in coordination with ongoing monitoring required under the facility's Stormwater General Permit. If discharges exceeding the limits of the Stormwater General Permit are identified during monitoring, or are deemed likely to re-contaminate the RAB, the EPA and Boeing will identify and implement additional source control measures (AMEC Geomatrix 2011, p. 8, Appendix A).

Pursuant to NRDA requirements, Boeing and the Elliot Bay Natural Resource Trustees agreed during December 2010 to additional habitat enhancement and mitigation measures to be completed concurrent with the RCRA action (AMEC Geomatrix 2011, p. 1). These related habitat enhancement and mitigation measures would restore and enhance approximately 4.8 acres of nearshore intertidal, wetland, and riparian habitat, including approximately 3,000 linear ft of shoreline, along and at the upstream and downstream limits of the cleanup area ("North Shoreline," "South Shoreline," and "Southwest Bank Shoreline Area," Figure 6)(AMEC Geomatrix 2011, pp. 5-7, 33). Some of this restoration and enhancement will be completed within the former footprint of the removed Boeing 2-40s Complex overwater structures and bulkheads (Figure 7). These habitat enhancement and mitigation measures will include creation of additional shallow intertidal habitat, functional wetland and riparian plantings, and features to support Tribal fishing access (AMEC Geomatrix 2011, pp. 5-7).

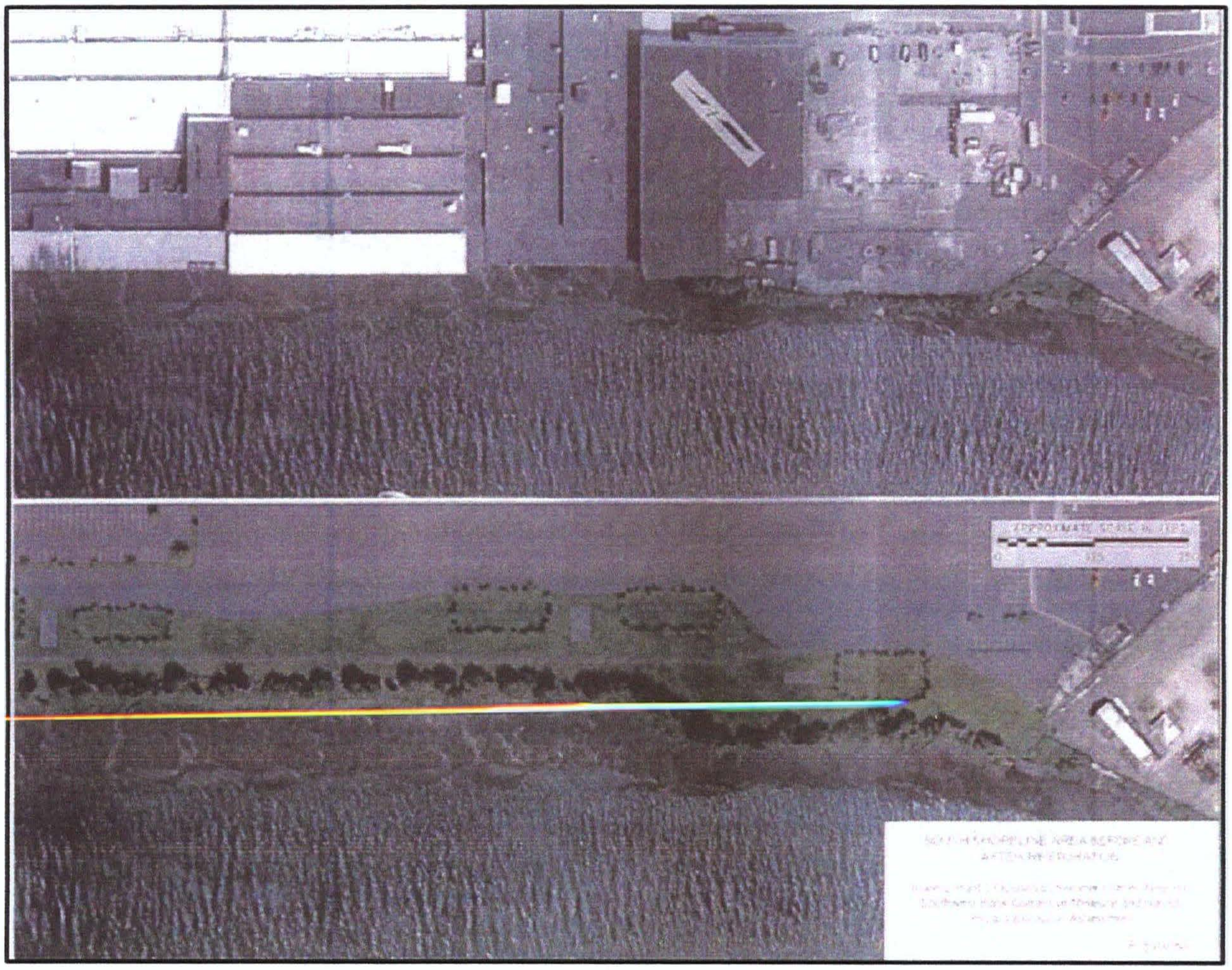

Figure 7. South Shoreline Restoration Area (AMEC Geomatrix 2011).

Conservation Measures

The EPA and their Applicants (Jorgensen Forge and Boeing) have identified a number of minimization measures and BMPs. Those descriptions are incorporated here by reference, except where they have been revised or amended as agreed to during the course of consultation and documented in correspondence between the EPA and the Service (Anchor QEA, in litt. 2012). What follows is a summary of those conservation measures which are common to each of the proposed cleanup and removal actions, and that are of particular relevance to the potential effects of the actions to bull trout and designated bull trout critical habitat.

- The EPA and Applicants will develop and implement spill prevention, control, and countermeasure plans (Spill Plans) to prevent the release of harmful or deleterious materials to the lower Duwamish, or to land with a possibility of re-entering the adjacent waterbody. The Spill Plan(s) shall identify designated refueling and equipment maintenance areas, specify physical and procedural BMPs, and provide for the security and containment of any stored fuels or other hazardous materials. The EPA and Applicants will regularly inspect and maintain all equipment, vessels, storage containers, and stockpiles to ensure proper function, and will proactively address any identified deficiencies.

- The EPA and Applicants will implement appropriate BMPs when demolishing and removing structures over or adjacent to the waterway (e.g., containment booms, tarps, etc.).

- All dredging will proceed according to an approved dredge plan(s), using bathymetric data and digital terrain models to ensure accurate bucket placement and targeting of materials. The EPA and Applicants will use stair-step dredge cuts on steeper slopes, will complete dredging within each sediment management unit (or sub-unit) as a single operation, and will in a timely manner place a thin (3 to 6 inch) sand cover over completed dredge cuts in each subunit, so as to prevent and minimize dredge residuals, sloughing, and re-suspension of contaminated sediment.

- To the fullest extent practicable, the EPA and Applicants will use an enclosed, environmental clamshell bucket when dredging, to minimize re-suspension of contaminated sediments. The EPA and Applicants will use a conventional clamshell bucket or grapple when/where coarse debris, dense sediment, or other obstructions prevent use of an enclosed, environmental clamshell bucket. An excavator dredge may be used on steeper slopes for improved bucket control.

- All wastes and contaminated media will be handled, stored, transported, tested, treated, and disposed in full compliance with all applicable State and Federal requirements. Creosote-treated wood and contaminated sediments and soil will be disposed at permitted and approved upland disposal sites accepting hazardous (Subtitle C) or non-hazardous (Subtitle D) solid wastes, as appropriate.

- Haul barges and scows used to contain and transport dredged sediment will be monitored to prevent over-filling, overflow, and/or direct discharge to the waterbody. The EPA and Applicants will take measures, as necessary, to actively dewater or remove water from dredged material, and will route the removed water to barge- and/or land-based water management systems designed to remove excess sediment and associated contaminants. The EPA and Applicants will ensure that all return water has been adequately treated to prevent exceedances of the State of Washington's surface water quality criteria beyond the edge of the allowable mixing-zone (or compliance boundary). All return water will be discharged to the lower Duwamish within the RABs.

- The EPA and Applicants will take all measures necessary, including temporary cessation of work, to prevent exceedances of the State of Washington's surface water quality criteria beyond the edge of the allowable mixing-zone (or compliance boundary). The EPA and Applicants will monitor surface water quality during the course of work to ensure compliance with applicable criteria, and to inform adaptive management and corrective response. [Note: the EPA and Applicants have tentatively identified an allowable mixing-zone/compliance boundary positioned approximately 150 ft upstream and downstream of sediment-generating activities.]

- All clean back-fill material will be from an approved source(s), and shall be free of any harmful or deleterious material.

- All temporary and permanent steel piles will be installed with a vibratory hammer or by direct-pushing. If the EPA and/or Applicants determine that impact pile driving is necessary to achieve the required substrate embeddedness and/or load-bearing capacity, they shall cease piling installation operations and provide timely notice to the Service.

- All in-water work located at elevations below +2 MLLW will be completed during the approved in-water work windows: Jorgensen Forge Facility and EAA-4 (August 1 to February 15); and, Boeing Plant 2 and DSOA (August 1 to February 15). Work located at elevations above +2 MLLW may be completed during low tides at any time of year.

- The EPA and Applicants will conduct post-construction monitoring and will adaptively manage any ongoing, un-controlled or incompletely controlled sources of contamination that originate from the Boeing or Jorgensen Forge EAA uplands. The EPA and Applicants will prevent re-contamination of the RABs to the fullest extent practicable. Post-construction monitoring will be performed in coordination with ongoing monitoring required under the applicable NPDES Stormwater General Permit(s). If this monitoring identifies discharges exceeding the limits of the Stormwater General Permit, or that are deemed likely to re-contaminate the RABs, the EPA and Applicants will identify and implement additional source control measures (AMEC Geomatrix 2011, p. 8, Appendix A; Anchor QEA, in litt. 2012, pp. 3, 4).

ACTION AREA

The action area is defined as all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). In delineating the action area, we evaluated the farthest reaching physical, chemical, and biotic effects of the action on the environment.

The terrestrial boundaries of the action area were defined based on the extent of temporary sound and visual disturbance that will result during construction. Temporary increases in sound associated with impact pile driving and proofing are expected to have the farthest reaching effects in the terrestrial environment. Increased sound levels will exceed ambient in-air sound levels to a distance of approximately 2 miles (Figure 8).

The aquatic boundaries of the action area were defined with consideration for where and how far work activities may temporarily increase underwater sound pressure levels (SPLs) as a result of piling installation operations, where temporary increases in turbidity and sedimentation may result from construction, and where and how far re-suspended sediments contaminated with PCBs, VOCs, dioxins/furans, and metals may travel before resettling. Downstream transport of fine-grained sediments (silts and clays) is expected to have the farthest reaching effects in the aquatic environment. The best available science would lead us to conclude that a portion of the re-suspended sediments, and the sediment-bound contaminant concentrations they carry, may travel the entire length of the lower Duwamish and into Elliot Bay (a distance of approximately 5 miles downstream) before falling out of suspension (Figure 8).

All wastes and contaminated media will be handled, stored, transported, tested, treated, and disposed in full compliance with all applicable State and Federal requirements. Creosote-treated wood and contaminated sediments and soil will be disposed at permitted and approved upland disposal sites accepting hazardous (Subtitle C) or non-hazardous (Subtitle D) solid wastes, as appropriate. Operations at these permitted and approved upland disposal sites, and any effects resulting from their operations, are not a focus of the Opinion, and therefore the Service does not include these sites in the action area defined for the Opinion.

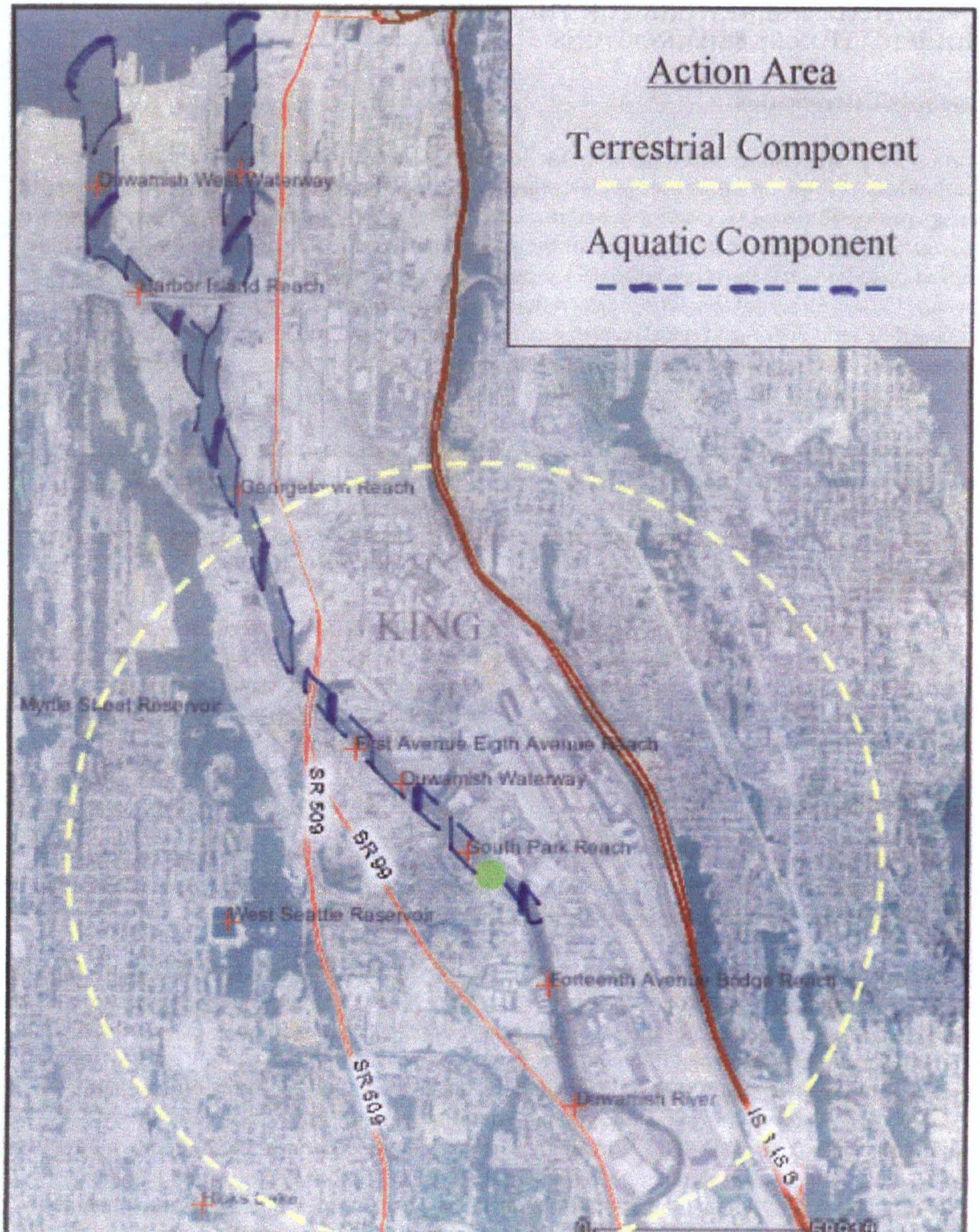

Figure 8. Aerial photo depicting extent of the action area.

ANALYTICAL FRAMEWORK FOR THE JEOPARDY AND ADVERSE MODIFICATION DETERMINATIONS

Jeopardy Determination

In accordance with policy and regulation, the jeopardy analysis in this Opinion relies on four components: (1) the *Status of the Species*, which evaluates the species' rangewide condition, the factors responsible for that condition, and its survival and recovery needs; (2) the *Environmental Baseline*, which evaluates the condition of the species in the action area, the factors responsible for that condition, and the relationship of the action area to the survival and recovery of the species; (3) the *Effects of the Action*, which determines the direct and indirect impacts of the proposed Federal action and the effects of any interrelated or interdependent activities on the species; and (4) *Cumulative Effects*, which evaluates the effects of future, non-Federal activities in the action area on the species.

In accordance with policy and regulation, the jeopardy determination is made by evaluating the effects of the proposed Federal action in the context of the species' current status, taking into account any cumulative effects, to determine if implementation of the proposed action is likely to cause an appreciable reduction in the likelihood of both the survival and recovery of the species in the wild.

The jeopardy analysis in this Opinion places an emphasis on consideration of the rangewide survival and recovery needs of the species and the role of the action area in the survival and recovery of the species as the context for evaluating the significance of the effects of the proposed Federal action, taken together with cumulative effects, for purposes of making the jeopardy determination.

Adverse Modification

This Opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statutory provisions of the Act to complete the following analysis with respect to critical habitat.

In accordance with policy and regulation, the adverse modification analysis in this Opinion relies on four components: (1) the *Status of Critical Habitat*, which evaluates the rangewide condition of designated critical habitat for the species in terms of primary constituent elements (PCEs), the factors responsible for that condition, and the intended recovery function of the critical habitat overall; (2) the *Environmental Baseline*, which evaluates the condition of the critical habitat in the action area, the factors responsible for that condition, and the recovery role of the critical habitat in the action area; (3) the *Effects of the Action*, which determines the direct and indirect impacts of the proposed Federal action and the effects of any interrelated or interdependent activities on the PCEs and how that will influence the recovery role of affected critical habitat units; and (4) *Cumulative Effects*, which evaluates the effects of future, non-Federal activities in the action area on the PCEs and how that will influence the recovery role of affected critical habitat units.

For purposes of the adverse modification determination, the effects of the proposed Federal action on critical habitat are evaluated in the context of the rangewide condition of the critical habitat, taking into account any cumulative effects, to determine if the critical habitat rangewide would remain functional (or would retain the current ability for the PCEs to be functionally established in areas of currently unsuitable but capable habitat) to serve its intended recovery role for the species.

The analysis in this Opinion places an emphasis on using the intended rangewide recovery function of critical habitat, and the role of the action area relative to that intended function as the context for evaluating the significance of the effects of the proposed Federal action, taken together with cumulative effects, for purposes of making the adverse modification determination.

STATUS OF THE SPECIES (BULL TROUT)

The rangewide status of the bull trout is provided in Appendix A.

STATUS OF CRITICAL HABITAT (BULL TROUT)

The rangewide status of bull trout critical habitat is provided in Appendix B.

ENVIRONMENTAL BASELINE

Regulations implementing the Act (50 CFR 402.02) define the environmental baseline as the past and present impacts of all Federal, State, or private actions and other human activities in the action area. Also included in the environmental baseline are the anticipated impacts of all proposed Federal projects in the action area that have undergone section 7 consultation, and the impacts of State and private actions which are contemporaneous with the consultation in progress.

Environmental Baseline in the Action Area

Land use throughout the action area is almost exclusively industrial, commercial/light-industrial, and dense urban residential. Lands within the action area are zoned General Industrial, Industrial Commercial, Industrial Buffer, Commercial, Neighborhood Commercial, Residential Multifamily, and Residential Single-Family (City of Seattle, Department of Planning and Development 2012). Throughout the action area the lower Duwamish and its floodplain are almost completely developed. Since the late 1800s these portions of the lower Duwamish River have been the focus of a long succession of flood control, navigational, port, industrial, and other activities (LDWG 2012b). Less than 2 percent of the lower Duwamish River's pre-development estuarine mud flat, sand flat, and intertidal wetland remains intact (KCDNRP and WSCC (Washington State Conservation Commission) 2000).

The lower Duwamish River plays an important role as migratory habitat for all salmon and steelhead of the Green-Duwamish watershed. These populations include: Green River Chinook salmon (*Oncorhynchus tshawytscha*; status rated as "healthy"), Duwamish/Green and Crisp Creek fall chum salmon (*O. keta*; status "unknown"), Green River/Soos Creek coho salmon (*O. kisutch*; status "healthy"), and Green River summer and winter steelhead (*O. mykiss*; status "depressed" and "healthy" respectively)(WDFW 2008). The waters within the action area are also presumed to support sea run coastal cutthroat trout (*O. clarki*), and anadromous bull trout have been documented in the project area. The lower Duwamish River and nearshore marine waters of Elliot Bay are designated as critical habitat for bull trout (50 FR 63898 [October 18, 2010]). These waters are also identified by the draft Bull Trout Recovery Plan as important foraging, migrating, and overwintering (FMO) habitat (USFWS 2004).

Factors that limit salmonid productivity in the action area include: floodplain modification and loss of hydrologic connectivity with estuarine wetlands, heavily degraded riparian conditions and a lack of mature woody vegetation, reduced instream habitat complexity (including channelization, bank hardening, reduced large woody material, degraded substrate conditions, and loss of pool, refuge, and off-channel habitat), impaired surface water and sediment quality, and loss or degradation of nearshore habitats and habitat forming processes (KCDNRP and WSCC (Washington State Conservation Commission) 2000).

The current baseline instream habitat and watershed conditions were assessed with the *Matrix of Diagnostics/Pathways and Indicators* (USFWS 1998). The matrix provides a framework for considering the effects of individual or grouped actions on habitat elements and processes important to the complete life cycle of bull trout. The BAs submitted by the EPA described baseline environmental conditions at the scale of the action area (AMEC Geomatrix 2011; Anchor QEA 2011a). Those descriptions are incorporated here by reference, and what follows is a brief summary: the waters within the action area are functioning at unacceptable levels of risk for 18 of 22 indicators, including temperature, chemical contamination/nutrients, substrate, pool frequency/quality, off-channel habitat, refugia, floodplain connectivity, and riparian reserves; and, the waters within the action area are not functioning adequately for any indicator, except width/depth ratio.

The Service has used additional information to characterize the chemical contamination indicator. The sub-section that follows presents information from the BAs and other sources as cited.

Chemical Contamination Indicator

The LDWG completed a final RI Report of the Lower Duwamish Waterway Superfund Site on July 9, 2010, for submittal to the EPA and Ecology (Windward Environmental 2010). The RI collected, sampled, and analyzed a great number of surface and subsurface sediment, surface and groundwater, and fish and shellfish tissue samples from locations throughout the lowermost six miles of the Duwamish River, and from the adjacent uplands (Windward Environmental 2010, p. ES-4). These data and analyses are too voluminous and cannot be concisely summarized here. The reader is directed, instead, to the RI Report for a full and complete discussion of contaminant concentrations and baseline risks to ecological and human health receptors.

Sediment Quality and Contamination

Throughout the lower Duwamish, including the proposed RABs, surface and subsurface sediments exhibit variable and discontinuous patterns of contamination (Figure 9). Some areas exhibit relatively high concentrations of one or more contaminants of concern, while other areas (even in close proximity) appear to contain only low concentrations (Windward Environmental 2010, p. ES-4). At some locations these bottom sediments contain a highly complex and variable mixture of PCBs, PAHs, dioxins/furans, VOCs, and metals. Tables 2 and 3 report summary statistics for select contaminants of concern from surface and subsurface sediments, respectively. Many of the highest concentrations are in areas identified as EAAs (Windward Environmental 2010, p. ES-4), as can be seen in Figure 9 for total PCB contaminant concentrations and their proximity to the proposed RABs.

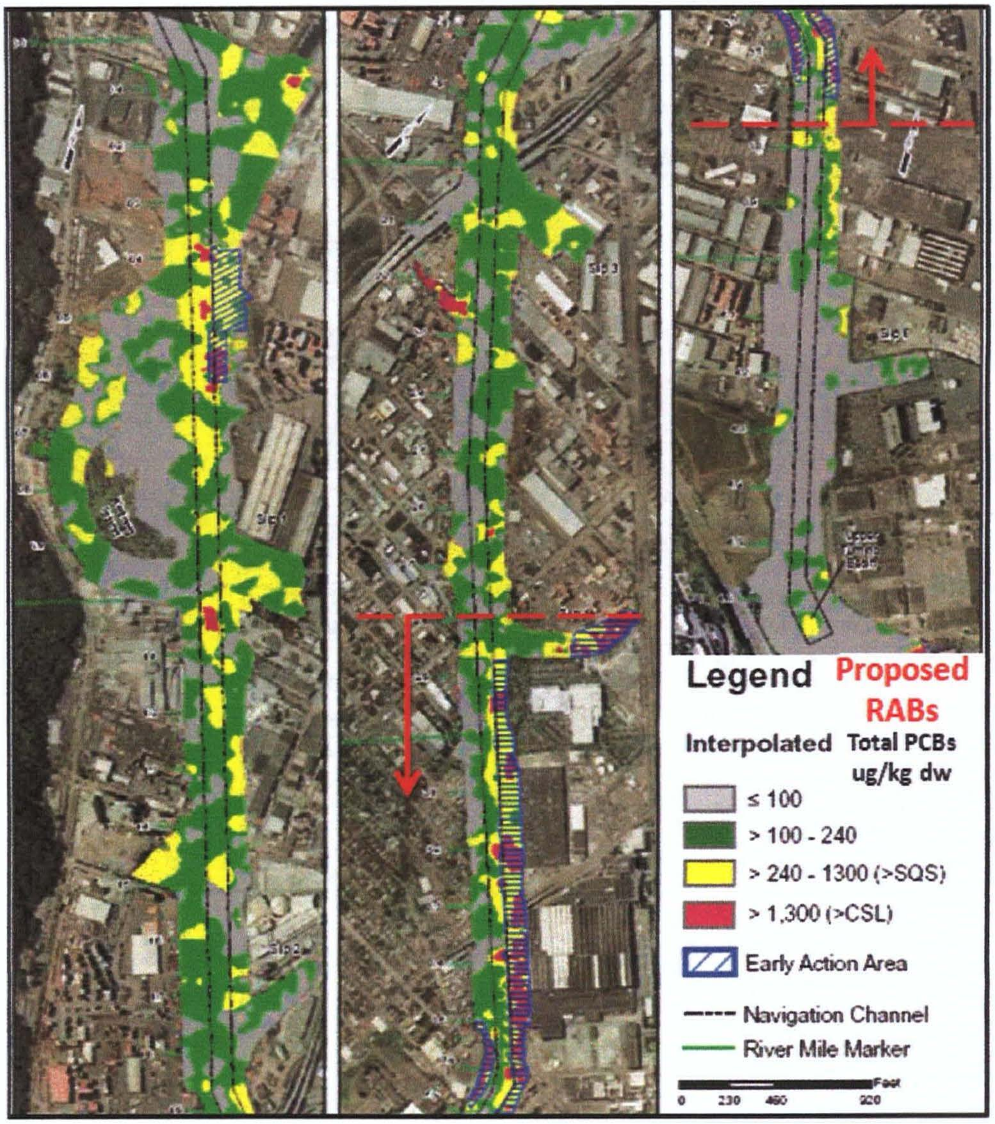

Figure 9. Sediment total PCB concentrations and RABs (AECOM 2010, p. ES-11).

Table 2. Summary statistics for select contaminants of concern in surface sediments (Windward Environmental 2010, p. ES-5).

Chemical	Unit	Detection Frequency	Concentration			
			Mean	Median	95th Percentile	Maximum
Total PCBs	µg/kg dw	1,243/1,327	1,170	137	4,300	220,000
Arsenic	mg/kg dw	794/852	17	11	30	1,100
cPAHs[a]	µg/kg dw	780/828	460	260	1,500	11,000
Dioxin and furan TEQ	ng/kg dw	54/54	82.1	10.4	490	2,100
BEHP	µg/kg dw	674/832	590	230	2,400	14,000

Note: summary statistics were calculated assuming one-half the reporting limit for non-detect results.

[a] cPAH concentrations are expressed in terms of benzo(a)pyrene equivalents.

dw – dry weight

BEHP – bis(2-ethylhexyl) phthalate

cPAH – carcinogenic polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

TEQ – toxic equivalent

Table 3. Summary statistics for select contaminants of concern in subsurface sediments (Windward Environmental 2010, p. ES-6).

Chemical	Unit	Detection Frequency[a]	Concentration				Depth Interval of Maximum Concentration (ft)[b]
			Mean	Median	95th Percentile	Maximum	
Total PCBs	µg/kg dw	609/821	3,000	170	5,600	890,000	0.3 – 1.5
Arsenic	mg/kg dw	267/325	40	12	63	2,000	2 – 4
cPAHs[c]	µg/kg dw	252/304	400	190	1,500	7,000	1 – 2
Dioxin and furan TEQ	ng/kg dw	26/26	27.2	14.4	170	194.0 J	4 – 6
BEHP	µg/kg dw	216/306	500	230	1,800	5,100	0 – 3

Note: summary statistics were calculated assuming one-half the reported or calculated non-detect results.

[a] Total number of samples represents all samples collected from any subsurface interval at all locations. Statistics are calculated based on all samples.

[b] Depth interval with highest concentration for a given chemical within any single core within the LDW.

[c] cPAH concentrations are expressed in terms of benzo(a)pyrene equivalents.

dw – dry weight

BEHP – bis(2-ethylhexyl) phthalate

cPAH – carcinogenic polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

TEQ – toxic equivalent

Table 4 reports data from the Draft Final Feasibility Study (AECOM 2010, pp. 2-63 thru 2-65), describing detection frequency and mean and maximum surface sediment concentrations for select contaminants of concern. Table 4 also provides a comparison with Washington State's marine sediment quality standards (SQSs).

Washington State's marine SQSs are established for the protection of marine biological resources and, "…correspond to a sediment quality that will result in … no acute or chronic adverse effects" (WAC 173-204-320). The State's marine cleanup screening levels (CSLs) are associated with "...minor adverse effects ... levels above which [locations] are defined as cleanup sites" (WAC 173-204-520). [Note: Ecology and the EPA have not consulted with the Service (or the National Marine Fisheries Service) regarding these criteria; the Service has not determined whether the application of these criteria will or may have adverse effects to listed species or critical habitat.]

Table 4. Detection frequency, mean and maximum surface sediment concentrations for select contaminants of concern; comparison with marine SQSs and CSLs.

Contaminant of Concern	Detection Frequency[a]	Mean Concentration[a]	Maximum Concentration[a]	WA Marine[b] SQS	WA Marine[c] CSL
Metals (mg/kg dry weight or parts per million)					
Copper	100%	106	12,000	390	390
Lead	100%	139	23,000	450	530
Zinc	100%	194	9,700	410	960
PAHs (µg/kg dry weight or parts per billion) *See Note Regarding Marine SQSs and CSLs[a] *					
Acenaphthene	39%	65	5,200	500	730
Anthracene	73%	134	10,000	960	4,400
Benzo(a)anthracene	92%	322	8,400	1,300	1,600
Benzo(a)pyrene	92%	308	7,900	1,600	3,000
Benzo(b)fluoranthene	94%	731	17,000	3,200	3,600
Benzo(g,h,i)perylene	86%	164	3,800	670	720
Benzo(k)fluoranthene	94%	731	17,000	3,200	3,600
Chrysene	95%	473	7,700	1,400	2,800
Dibenzo(a,h)anthracene	56%	62	1,500	230	540
Fluoranthene	97%	887	24,000	1,700	2,500
Fluorene	48%	78	6,800	540	1,000
Indeno(1,2,3-c,d)pyrene	90%	180	4,300	600	690
Phenanthrene	93%	429	28,000	1,500	5,400
Pyrene	96%	723	16,000	2,600	3,300
Total H-PAHs	98%	3,809	85,000	12,000	17,000
Total L-PAHs	94%	696	44,000	5,200	13,000
PCBs (µg/kg dry weight or parts per billion) *See Note Regarding Marine SQSs and CSLs[a] *					
Total PCBs	94%	1,133	223,000	130	1,000
Phthalates (µg/kg dry weight or parts per billion) *See Note Regarding Marine SQSs and CSLs[a] *					
Bis(2-ethylhexyl) phthalate [BEHP]	79%	589	17,000	1,300	1,900
Butyl benzyl phthalate [BBP]	54%	87	7,100	63	900
Dimethyl phthalate	21%	25	440	71	160

Sources: [a](AECOM 2010, pp. 2-63 thru 2-65); [b]WAC 173-204-320; [c]WAC 173-204-520

a Many of Washington State's Marine SQSs and CSLs are normalized for organic carbon; for ease of comparison, the criteria reported here are taken from Windward Environmental (2010, pp. 170-171) and represent functional equivalents expressed as dry weight.

Data from Table 4 allow us to make the following statements regarding contaminants of concern and their presence in lower Duwamish surface sediments:

- PCBs - PCBs were detected in 94 percent of the samples from the baseline dataset. The mean surface sediment total PCB concentration exceeds the marine CSL. The maximum surface sediment total PCB concentration exceeds the marine CSL by more than two orders of magnitude.

- Metals - Copper, lead, and zinc were detected in 100 percent of the samples from the baseline dataset. Mean surface sediment metal concentrations are below both the marine SQSs and CSLs. However, maximum surface sediment metal concentrations exceed the marine SQSs and CSLs by at least one order of magnitude.

- PAHs - High- and low-molecular weight PAHs (H-PAHs and L-PAHs) were detected in 98 percent and 94 percent of the samples from the baseline dataset, respectively. Mean surface sediment total H-PAH and L-PAH concentrations are below both the marine SQSs and CSLs. However, maximum surface sediment total H-PAH and L-PAH concentrations are three to five times greater than the marine CSLs.

- Phthalates - Bis(2-ethylhexyl) phthalate (BEHP) and Butyl benzyl phthalate (BBP) were detected in 79 percent and 54 percent of the samples from the baseline dataset, respectively. Maximum surface sediment BEHP and BBP concentrations are seven to nine times greater than the marine CSLs.

Samples taken from sediment cores detect many of the same contaminants of concern below the surface sediment layer (Windward Environmental 2010, p. ES-5). Even though some of the highest contaminant concentrations have been detected in subsurface samples, most notably for total PCBs and arsenic, the depth interval of maximum concentration is located within 4 ft of the surface sediment layer for most contaminants of concern, and the 95th percentile contaminant concentrations in surface and subsurface sediments are generally comparable (Tables 2 and 3).

Water Quality

The RI Report summarizes surface water quality data for the lowermost portions of the Duwamish River (Windward Environmental 2010). The report describes widespread, detectable concentrations of PCBs, PAHs, VOCs, metals, and some pesticides, but does not document exceedances of State of Washington surface water quality criteria for these parameters (AMEC Geomatrix 2011, p. 28).

The current 303(d) list of impaired waterbodies identifies portions of the Duwamish Waterway as Category 4 and 5 polluted waters, for exceedances of the fecal coliform, ammonia, and dissolved oxygen criteria (WDOE 2008). In addition, the EPA and LDWG report that these waters frequently fail to meet criteria for pH and water temperature (AMEC Geomatrix 2011, p. 28; Windward Environmental 2010, p. 630).

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APPENDIX B: Status of Designated Critical Habitat (Bull Trout; Coterminous Range)

Appendix B:
Status of Designated Critical Habitat (Bull Trout; Coterminous Range)

Legal Status

Current Designation

The Service published a final critical habitat designation for the coterminous United States population of the bull trout on October 18, 2010 (70 FR 63898); the rule becomes effective on November 17, 2010. A justification document was also developed to support the rule and is available on our website (http://www.fws.gov/pacific/bulltrout). The scope of the designation involved the species' coterminous range, which includes the Jarbidge River, Klamath River, Columbia River, Coastal-Puget Sound, and Saint Mary-Belly River population segments (also considered as interim recovery units)1. Rangewide, the Service designated reservoirs/lakes and stream/shoreline miles as bull trout critical habitat (Table 1). Designated bull trout critical habitat is of two primary use types: 1) spawning and rearing, and 2) foraging, migration, and overwintering (FMO).

Table 1. Stream/shoreline distance and reservoir/lake area designated as bull trout critical habitat by state.

State	Stream/Shoreline Miles	Stream/Shoreline Kilometers	Reservoir /Lake Acres	Reservoir/ Lake Hectares
Idaho	8,771.6	14,116.5	170,217.5	68,884.9
Montana	3,056.5	4,918.9	221,470.7	89,626.4
Nevada	71.8	115.6	-	-
Oregon	2,835.9	4,563.9	30,255.5	12,244.0
Oregon/Idaho	107.7	173.3	-	-
Washington	3,793.3	6,104.8	66,308.1	26,834.0
Washington (marine)	753.8	1,213.2	-	-
Washington/Idaho	37.2	59.9	-	-
Washington/Oregon	301.3	484.8	-	-
Total	19,729.0	31,750.8	488,251.7	197,589.2

The 2010 revision increases the amount of designated bull trout critical habitat by approximately 76 percent for miles of stream/shoreline and by approximately 71 percent for acres of lakes and reservoirs compared to the 2005 designation.

This rule also identifies and designates as critical habitat approximately 1,323.7 km (822.5 miles) of streams/shorelines and 6,758.8 ha (16,701.3 acres) of lakes/reservoirs of unoccupied habitat to address bull trout conservation needs in specific geographic areas in several areas not occupied at the time of listing. No unoccupied habitat was included in the 2005 designation. These

1 The Service's 5 year review (USFWS 2008, pg. 9) identifies six draft recovery units. Until the bull trout draft recovery plan is finalized, the current five interim recovery units are in affect for purposes of section 7 jeopardy analysis and recovery. The adverse modification analysis does not rely on recovery units.

unoccupied areas were determined by the Service to be essential for restoring functioning migratory bull trout populations based on currently available scientific information. These unoccupied areas often include lower main stem river environments that can provide seasonally important migration habitat for bull trout. This type of habitat is essential in areas where bull trout habitat and population loss over time necessitates reestablishing bull trout in currently unoccupied habitat areas to achieve recovery.

The final rule continues to exclude some critical habitat segments based on a careful balancing of the benefits of inclusion versus the benefits of exclusion. Critical habitat does not include: 1) waters adjacent to non-Federal lands covered by legally operative incidental take permits for habitat conservation plans (HCPs) issued under section 10(a)(1)(B) of the Endangered Species Act of 1973, as amended (Act), in which bull trout is a covered species on or before the publication of this final rule; 2) waters within or adjacent to Tribal lands subject to certain commitments to conserve bull trout or a conservation program that provides aquatic resource protection and restoration through collaborative efforts, and where the Tribes indicated that inclusion would impair their relationship with the Service; or 3) waters where impacts to national security have been identified (75 FR 63898). Excluded areas are approximately 10 percent of the stream/shoreline miles and 4 percent of the lakes and reservoir acreage of designated critical habitat. Each excluded area is identified in the relevant Critical Habitat Unit (CHU) text, as identified in paragraphs (e)(8) through (e)(41) of the final rule. See Tables 2 and 3 for the list of excluded areas. It is important to note that the exclusion of waterbodies from designated critical habitat does not negate or diminish their importance for bull trout conservation. Because exclusions reflect the often complex pattern of land ownership, designated critical habitat is often fragmented and interspersed with excluded stream segments.

Table 2.—Stream/shoreline distance excluded from bull trout critical habitat based on tribal ownership or other plan.

Ownership and/or Plan	Kilometers	Miles
Lewis River Hydro Conservation Easements	7.0	4.3
DOD – Dabob Bay Naval	23.9	14.8
HCP – Cedar River (City of Seattle)	25.8	16.0
HCP – Washington Forest Practices Lands	1,608.30	999.4
HCP – Green Diamond (Simpson)	104.2	64.7
HCP – Plum Creek Central Cascades (WA)	15.8	9.8
HCP – Plum Creek Native Fish (MT)	181.6	112.8
HCP–Stimson	7.7	4.8
HCP – WDNR Lands	230.9	149.5
Tribal – Blackfeet	82.1	51.0
Tribal – Hoh	4.0	2.5
Tribal – Jamestown S'Klallam	2.0	1.2
Tribal – Lower Elwha	4.6	2.8
Tribal – Lummi	56.7	35.3
Tribal – Muckleshoot	9.3	5.8
Tribal – Nooksack	8.3	5.1
Tribal – Puyallup	33.0	20.5
Tribal – Quileute	4.0	2.5

Ownership and/or Plan	Kilometers	Miles
Tribal – Quinault	153.7	95.5
Tribal – Skokomish	26.2	16.3
Tribal – Stillaguamish	1.8	1.1
Tribal – Swinomish	45.2	28.1
Tribal – Tulalip	27.8	17.3
Tribal – Umatilla	62.6	38.9
Tribal – Warm Springs	260.5	161.9
Tribal – Yakama	107.9	67.1
Total	3,094.9	1,923.1

Table 3. Lake/Reservoir area excluded from bull trout critical habitat based on tribal ownership or other plan.

Ownership and/or Plan	Hectares	Acres
HCP – Cedar River (City of Seattle)	796.5	1,968.2
HCP – Washington Forest Practices Lands	5,689.1	14,058.1
HCP – Plum Creek Native Fish	32.2	79.7
Tribal – Blackfeet	886.1	2,189.5
Tribal – Warm Springs	445.3	1,100.4
Total	7,849.3	19,395.8

Conservation Role and Description of Critical Habitat

The conservation role of bull trout critical habitat is to support viable core area populations (75 FR 63898:63943 [October 18, 2010]). The core areas reflect the metapopulation structure of bull trout and are the closest approximation of a biologically functioning unit for the purposes of recovery planning and risk analyses. CHUs generally encompass one or more core areas and may include FMO areas, outside of core areas, that are important to the survival and recovery of bull trout.

Thirty-two CHUs within the geographical area occupied by the species at the time of listing are designated under the revised rule. Twenty-nine of the CHUs contain all of the physical or biological features identified in this final rule and support multiple life-history requirements. Three of the mainstem river units in the Columbia and Snake River basins contain most of the physical or biological features necessary to support the bull trout's particular use of that habitat, other than those physical biological features associated with Primary Constituent Elements (PCEs) 5 and 6, which relate to breeding habitat.

The primary function of individual CHUs is to maintain and support core areas, which 1) contain bull trout populations with the demographic characteristics needed to ensure their persistence and contain the habitat needed to sustain those characteristics (Rieman and McIntyre 1993, p. 19); 2) provide for persistence of strong local populations, in part, by providing habitat conditions that encourage movement of migratory fish (MBTSG 1998, pp. 48-49; Rieman and McIntyre 1993, pp. 22-23); 3) are large enough to incorporate genetic and phenotypic diversity, but small enough to ensure connectivity between populations (Hard 1995, pp. 314-315; Healey and Prince 1995, p. 182; MBTSG 1998, pp. 48-49; Rieman and McIntyre 1993, pp. 22-23); and 4) are distributed throughout the historic range of the species to preserve both genetic and phenotypic adaptations (Hard 1995, pp. 321-322; MBTSG 1998, pp. 13-16; Rieman and Allendorf 2001, p. 763; Rieman and McIntyre 1993, p. 23).

The Olympic Peninsula and Puget Sound CHUs are essential to the conservation of amphidromous bull trout, which are unique to the Coastal-Puget Sound population segment. These CHUs contain marine nearshore and freshwater habitats, outside of core areas, that are used by bull trout from one or more core areas. These habitats, outside of core areas, contain PCEs that are critical to adult and subadult foraging, overwintering, and migration.

Primary Constituent Elements for Bull Trout

Within the designated critical habitat areas, the PCEs for bull trout are those habitat components that are essential for the primary biological needs of foraging, reproducing, rearing of young, dispersal, genetic exchange, or sheltering. Based on our current knowledge of the life history, biology, and ecology of this species and the characteristics of the habitat necessary to sustain its essential life-history functions, we have determined that the following PCEs are essential for the conservation of bull trout.

1. Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.

2. Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.

3. An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

4. Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks and unembedded substrates, to provide a variety of depths, gradients, velocities, and structure.

5. Water temperatures ranging from 2 °C to 15 °C (36 °F to 59 °F), with adequate thermal refugia available for temperatures that exceed the upper end of this range. Specific temperatures within this range will depend on bull trout life-history stage and form; geography; elevation; diurnal and seasonal variation; shading, such as that provided by riparian habitat; streamflow; and local groundwater influence.

6. In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival. A minimal amount of fine sediment, generally ranging in size from silt to coarse sand, embedded in larger substrates, is characteristic of these conditions. The size and amounts of fine sediment suitable to bull trout will likely vary from system to system.

7. A natural hydrograph, including peak, high, low, and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.

8. Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

9. Sufficiently low levels of occurrence of non-native predatory (e.g., lake trout, walleye, northern pike, smallmouth bass); interbreeding (e.g., brook trout); or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

The revised PCE's are similar to those previously in effect under the 2005 designation. The most significant modification is the addition of a ninth PCE to address the presence of nonnative predatory or competitive fish species. Although this PCE applies to both the freshwater and marine environments, currently no non-native fish species are of concern in the marine environment, though this could change in the future.

Note that only PCEs 2, 3, 4, 5, and 8 apply to marine nearshore waters identified as critical habitat. Also, lakes and reservoirs within the CHUs also contain most of the physical or biological features necessary to support bull trout, with the exception of those associated with PCEs 1 and 6. Additionally, all except PCE 6 apply to FMO habitat designated as critical habitat.

Critical habitat includes the stream channels within the designated stream reaches and has a lateral extent as defined by the bankfull elevation on one bank to the bankfull elevation on the opposite bank. Bankfull elevation is the level at which water begins to leave the channel and move into the floodplain and is reached at a discharge that generally has a recurrence interval of 1 to 2 years on the annual flood series. If bankfull elevation is not evident on either bank, the ordinary high-water line must be used to determine the lateral extent of critical habitat. The lateral extent of designated lakes is defined by the perimeter of the waterbody as mapped on standard 1:24,000 scale topographic maps. The Service assumes in many cases this is the full-pool level of the waterbody. In areas where only one side of the waterbody is designated (where only one side is excluded), the mid-line of the waterbody represents the lateral extent of critical habitat.

In marine nearshore areas, the inshore extent of critical habitat is the mean higher high-water (MHHW) line, including the uppermost reach of the saltwater wedge within tidally influenced freshwater heads of estuaries. The MHHW line refers to the average of all the higher high-water heights of the two daily tidal levels. Marine critical habitat extends offshore to the depth of 10 meters (m) (33 ft) relative to the mean low low-water (MLLW) line (zero tidal level or average of all the lower low-water heights of the two daily tidal levels). This area between the MHHW line and minus 10 m MLLW line (the average extent of the photic zone) is considered the habitat most consistently used by bull trout in marine waters based on known use, forage fish availability, and ongoing migration studies and captures geological and ecological processes important to maintaining these habitats. This area contains essential foraging habitat and migration corridors such as estuaries, bays, inlets, shallow subtidal areas, and intertidal flats.

Adjacent shoreline riparian areas, bluffs, and uplands are not designated as critical habitat. However, it should be recognized that the quality of marine and freshwater habitat along streams, lakes, and shorelines is intrinsically related to the character of these adjacent features, and that human activities that occur outside of the designated critical habitat can have major effects on physical and biological features of the aquatic environment.

Activities that cause adverse effects to critical habitat are evaluated to determine if they are likely to "destroy or adversely modify" critical habitat by no longer serving the intended conservation role for the species or retaining those PCEs that relate to the ability of the area to at least periodically support the species. Activities that may destroy or adversely modify critical habitat are those that alter the PCEs to such an extent that the conservation value of critical habitat is appreciably reduced (75 FR 63898:63943; USFWS 2004, Vol. 1. pp. 140-193, Vol. 2. pp. 69-114). The Service's evaluation must be conducted at the scale of the entire critical habitat area designated, unless otherwise stated in the final critical habitat rule (USFWS and NMFS 1998, pp. 4-39). Thus, adverse modification of bull trout critical habitat is evaluated at the scale of the final designation, which includes the critical habitat designated for the Klamath River, Jarbidge River, Columbia River, Coastal-Puget Sound, and Saint Mary-Belly River population segments. However, we consider all 32 CHUs to contain features or areas essential to the conservation of the bull trout (75 FR 63898:63901, 63944). Therefore, if a proposed action would alter the physical or biological features of critical habitat to an extent that appreciably reduces the conservation function of one or more critical habitat units for bull trout, a finding of adverse modification of the entire designated critical habitat area may be warranted (75 FR 63898:63943).

Current Critical Habitat Condition Rangewide

The condition of bull trout critical habitat varies across its range from poor to good. Although still relatively widely distributed across its historic range, the bull trout occurs in low numbers in many areas, and populations are considered depressed or declining across much of its range (67 FR 71240). This condition reflects the condition of bull trout habitat. The decline of bull trout is primarily due to habitat degradation and fragmentation, blockage of migratory corridors, poor water quality, past fisheries management practices, impoundments, dams, water diversions, and the introduction of nonnative species (63 FR 31647, June 10 1998; 64 FR 17112, April 8, 1999).

There is widespread agreement in the scientific literature that many factors related to human activities have impacted bull trout and their habitat, and continue to do so. Among the many factors that contribute to degraded PCEs, those which appear to be particularly significant and have resulted in a legacy of degraded habitat conditions are as follows: 1) fragmentation and isolation of local populations due to the proliferation of dams and water diversions that have eliminated habitat, altered water flow and temperature regimes, and impeded migratory movements (Dunham and Rieman 1999, p. 652; Rieman and McIntyre 1993, p. 7); 2) degradation of spawning and rearing habitat and upper watershed areas, particularly alterations in sedimentation rates and water temperature, resulting from forest and rangeland practices and intensive development of roads (Fraley and Shepard 1989, p. 141; MBTSG 1998, pp. ii - v, 20-45); 3) the introduction and spread of nonnative fish species, particularly brook trout and lake trout, as a result of fish stocking and degraded habitat conditions, which compete with bull trout for limited resources and, in the case of brook trout, hybridize with bull trout (Leary et al. 1993, p. 857; Rieman et al. 2006, pp. 73-76); 4) in the Coastal-Puget Sound region where amphidromous bull trout occur, degradation of mainstem river FMO habitat, and the degradation and loss of marine nearshore foraging and migration habitat due to urban and residential development; and 5) degradation of FMO habitat resulting from reduced prey base, roads, agriculture, development, and dams.

Effects of Climate Change on Bull Trout Critical Habitat

One objective of the final rule was to identify and protect those habitats that provide resiliency for bull trout use in the face of climate change. Over a period of decades, climate change may directly threaten the integrity of the essential physical or biological features described in PCEs 1, 2, 3, 5, 7, 8, and 9. Protecting bull trout strongholds and cold water refugia from disturbance and ensuring connectivity among populations were important considerations in addressing this potential impact. Additionally, climate change may exacerbate habitat degradation impacts both physically (e.g., decreased base flows, increased water temperatures) and biologically (e.g., increased competition with non-native fishes).

Consulted on Effects for Critical Habitat

The Service has formally consulted on the effects to bull trout critical habitat throughout its range. Section 7 consultations include actions that continue to degrade the environmental baseline in many cases. However, long-term restoration efforts have also been implemented that provide some improvement in the existing functions within some of the critical habitat units.

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APPENDIX C: Core Area Summaries (Bull Trout)

Appendix C: Core Area Summaries (Bull Trout)

Puyallup Core Area

The Puyallup core area comprises the Puyallup, Mowich, and Carbon Rivers; the White River system, which includes the Clearwater, Greenwater, and the West Fork White Rivers; and Huckleberry Creek. Glacial sources in several watersheds drain the north and west sides of Mount Rainier and significantly influence water, substrate, and channel conditions in the mainstem reaches. The location of many of the basin's headwater reaches within Mount Rainier National Park and designated wilderness areas (Clearwater Wilderness, Norse Peak Wilderness) provides relatively pristine habitat conditions in these portions of the watershed.

Anadromous, fluvial, and potentially resident bull trout occur within local populations in the Puyallup River system. Bull trout occur throughout most of the system although spawning occurs primarily in the headwater reaches. Anadromous and fluvial bull trout use the mainstem reaches of the Puyallup, Carbon, and White Rivers to forage and overwinter, while the anadromous form also uses Commencement Bay and likely other nearshore areas within Puget Sound. Habitat conditions within the lower mainstem Puyallup and White Rivers have been highly degraded, retaining minimal instream habitat complexity. In addition, habitat conditions within Commencement Bay and adjoining nearshore areas have been severely degraded as well, with very little intact intertidal habitat remaining.

The Puyallup core area has the southernmost, anadromous bull trout population in the Puget Sound Management Unit (USFWS 2004, Vol. 2 p. 19). Consequently, maintaining the bull trout population in this core area is critical to maintaining the overall distribution of migratory bull trout in the management unit.

The status of the bull trout core area population is based on four key elements necessary for long-term viability: 1) number and distribution of local populations, 2) adult abundance, 3) productivity, and 4) connectivity (USFWS 2004, Vol 2 p. 215).

<u>Number and Distribution of Local Populations</u>

Five local populations occur in the Puyallup core area: 1) Upper Puyallup and Mowich Rivers, 2) Carbon River, 3) Upper White River, 4) West Fork White River, and 5) Greenwater River. The Clearwater River is identified as a potential local population, as bull trout are known to use this river and it appears to provide suitable spawning habitat, but the occurrence of reproduction there is unknown (USFWS 2004, Vol 2 pp. 119-121).

Information about the distribution and abundance of bull trout in this core area is limited because observations have generally been incidental to other fish species survey work. Spawning occurs in the upper reaches of this basin where higher elevations produce the cold water temperatures required by bull trout egg and juvenile survival. Based on current survey data, bull trout spawning in this core area occurs earlier in the year (i.e., September) than typically observed in other Puget Sound core areas (Marks et al. 2002). The known spawning areas in local populations are few in number and not widespread. The majority of spawning sites are located in streams within Mount Rainier National Park, with two exceptions, Silver Creek and Silver Springs (Ladley, in litt. 2006; Marks et al. 2002).

Rearing likely occurs throughout the Upper Puyallup, Mowich, Carbon, Upper White, West Fork White, and Greenwater Rivers. However, sampling indicates most rearing is confined to the upper reaches of the basin. The mainstem reaches of the White, Carbon, and Puyallup Rivers probably provide the primary freshwater foraging, migration, and overwintering habitat for migratory bull trout within this core area.

With fewer than 10 local populations, the Puyallup core area is considered to be at intermediate risk of extirpation and adverse effects from random naturally occurring events.

Adult Abundance

Rigorous abundance estimates are generally not available for local populations in the Puyallup core area. Currently, fewer than 100 adults probably occur in each of the local populations in the White River system, based on adult counts at Mud Mountain Dam's Buckley Diversion fish trap. Although these counts may not adequately account for fluvial migrants that do not migrate downstream of the facility, these counts do indicate few anadromous bull trout and few mainstem fluvial bull trout return to local populations in the White River system. Therefore, the bull trout population in the Puyallup core area is considered at increased risk of extirpation until sufficient information is collected to properly assess adult abundance in each local population.

Productivity

Due to the current lack of long-term, comprehensive trend data, the bull trout population in the Puyallup core area is considered at increased risk of extirpation until sufficient information is collected to properly assess productivity.

Connectivity

Migratory bull trout are likely present in most local populations in the Puyallup core area. However, the number of adult bull trout expressing migratory behavior within each local population appears to be very low compared to other core areas. Although connectivity between the Upper Puyallup and Mowich Rivers local population and other Puyallup core area local populations was reestablished with the creation of an upstream fish ladder at Electron Dam in 2000, this occurred after approximately 100 years of isolation. Very low numbers of migratory bull trout continue to be passed upstream at the Mud Mountain Dam's Buckley Diversion fish trap. The overall low abundance of migratory life history forms limits the possibility for genetic exchange and local population refounding, as well as limits more diverse foraging opportunities to increase size of spawners and therefore, overall fecundity within the population. Consequently, the bull trout population in the Puyallup core area is at intermediate risk of extirpation from habitat isolation and fragmentation.

Changes in Environmental Conditions and Population Status

Since the bull trout listing, the Service has issued Biological Opinions that exempted incidental take in the Puyallup core area. These incidental take exemptions were in the form of harm and harassment, primarily from hydrologic impacts associated with increased impervious surface, temporary sediment increases during in-water work, habitat loss or alteration, and handling of fish. None of these projects were determined to result in jeopardy to bull trout. The combined effects of actions evaluated under these Biological Opinions have resulted in short-term and long-term adverse effects to bull trout and degradation of bull trout habitat within the core area.

Of particular note, in 2003 the Service issued a Biological Opinion (FWS Ref. No. 1-3-01-F-0476) on the State Route 167 North Sumner Interchange Project. This project was located in Pierce County in the White River portion of the Puyallup watershed and was proposed by Washington State Department of Transportation. The project's direct and indirect impacts and cumulative impacts within the action area included urbanization of approximately 600 acres of land. We anticipated that conversion of this land to impervious surface would result in the permanent loss and/or degradation of aquatic habitat for bull trout and their prey species through reduced base flows, increased peak flows, increased temperatures, loss of thermal refugia, degradation of water quality, and the degradation of the aquatic invertebrate community and those species dependent upon it (bull trout prey species). These impacts will result in thermal stress and disrupt normal behavioral patterns. Incidental take of fluvial, adfluvial, and anadromous bull trout in the form of harassment due to thermal stress and the disruption of migrating and foraging behaviors was exempted for this project. These adverse effects were expected to continue in perpetuity.

Section 10(a)(1)(B) permits have also been issued for HCPs that address bull trout in this core area. Although these HCPs may result in both short and/or long-term negative effects to bull trout and their habitat, the anticipated long-term beneficial effects are expected to maintain or improve the overall baseline status of the species. Additionally, capture and handling, and indirect mortality, during implementation of section 6 and section 10(a)(1)(A) permits have directly affected some individual bull trout in this core area.

The number of non-Federal actions occurring within the Puyallup core area since the bull trout were listed is unknown. However, activities conducted on a regular basis, such as emergency flood control, development, and infrastructure maintenance affect riparian and instream habitat which typically results in negative affects to bull trout and their habitat.

Threats

Threats to bull trout in the Puyallup core area include:

- Extensive past and ongoing timber harvest and harvest-related activities, such as road maintenance and construction, continue to affect bull trout spawning and rearing areas in the upper watershed.

- Agricultural practices, such as bank armoring, riparian clearing, and non-point discharges of chemical applications continue to affect foraging, migration, and overwintering habitats for bull trout in the lower watershed.
- Dams and diversions have significantly affected migratory bull trout in the core area. Until upstream passage was recently restored, the Electron Diversion Dam isolated bull trout in the Upper Puyallup and Mowich Rivers local population for nearly 100 years and has drastically reduced the abundance of migratory bull trout in the Puyallup River. Buckley Diversion and Mud Mountain Dam have significantly affected the White River system in the past by impeding or precluding adult and juvenile migration and degrading foraging, migration, and overwintering habitats in the mainstem. Despite improvements to these facilities, passage related impacts continue today but to a lesser degree.
- Urbanization, road construction, residential development, and marine port development associated with the city of Tacoma, have significantly reduced habitat complexity and quality in the lower mainstem rivers and associated tributaries, and have largely eliminated intact nearshore foraging habitats for anadromous bull trout in Commencement Bay.
- The presence of brook trout in many parts of the Puyallup core area and their potential to increase in distribution, including into Mount Rainer National Park waters, are considered significant threats to bull trout. Because of their early maturation and competitive advantage over bull trout in degraded habitats, brook trout in the upper Puyallup and Mowich Rivers local population is of highest concern because of past isolation of bull trout and the level of habitat degradation in this area.
- Until the early 1990s, bull trout fisheries probably significantly reduced the overall bull trout population within this and other core areas in Puget Sound. Current legal and illegal fisheries in the Puyallup core area may continue to significantly limit recovery of the population because of the low numbers of migratory adults.
- Water quality has been degraded due to municipal and industrial effluent discharges resulting from development, particularly in the lower mainstem Puyallup River and Commencement Bay.
- Water quality has also been degraded by stormwater discharge associated with runoff from impervious surface. Impervious surface in the Puyallup watershed increased by 12 percent between 1990 and 2001 (PSAT 2007).
- Major flood events in November 2006 significantly impacted instream habitats within the Puyallup River system. These events are assumed to have drastically impacted bull trout brood success for the year, due to significant scour and channel changes that occurred after peak spawning. Significant impacts to rearing juvenile bull trout were also likely, further impacting the future recruitment of adult bull trout.
- In November 2006, an 18,000 gallon diesel spill in the head waters of Spring Creek (Hebert, in litt. 2006), a bull trout spawning area of the Upper White River local population, likely impacted the available instream spawning habitat. The duration of ongoing contamination of instream habitats by residual diesel is unknown.

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Snohomish-Skykomish Core Area

The Snohomish-Skykomish core area comprises the Snohomish, Skykomish, and Snoqualmie Rivers and their tributaries. Bull trout occur throughout the Snohomish River system downstream of barriers to anadromous fish. Bull trout are not known to occur upstream of Snoqualmie Falls, upstream of Spada Lake on the Sultan River, in the upper forks of the Tolt River, above Deer Falls on the North Fork Skykomish River, or above Alpine Falls on the Tye River.

Fluvial, resident, and anadromous life history forms of bull trout occur in the Snohomish River/Skykomish core area. A large portion of the migratory segment of this population is anadromous. There are no lake systems within the basin that support an adfluvial population. However, anadromous and fluvial forms occasionally forage in a number of lowland lakes connected to the mainstem rivers.

The mainstems of the Snohomish, Skykomish, North Skykomish, and South Fork Skykomish Rivers provide important foraging, migrating, and overwintering habitat for subadult and adult bull trout. The amount of key spawning and early rearing habitat is more limited, in comparison with many other core areas, because of the topography of the basin. Rearing bull trout occur throughout most of the accessible reaches of the basin and extensively use the lower estuary, nearshore marine areas, and Puget Sound for extended rearing.

The status of the bull trout core area population is based on four key elements necessary for long-term viability: 1) number and distribution of local populations, 2) adult abundance, 3) productivity, and 4) connectivity (USFWS 2004, Vol. 1, p. 215).

Number and Distribution of Local Populations

Four local populations have been identified: (1) North Fork Skykomish River (including Goblin and West Cady Creeks), (2) Troublesome Creek (resident form only), (3) Salmon Creek, and (4) South Fork Skykomish River. With only four local populations, bull trout in this core area are considered at increased risk of extirpation and adverse effects from random naturally occurring events (see "Life History" in Bull Trout Status of the Species, in Appendices, p. 5).

Adult Abundance

The Snohomish-Skykomish core area probably supports between 500 and 1,000 adults. However, this core area remains at risk of genetic drift. Most of the spawners in the core area occur in the North Fork Skykomish local population. Redd counts within the North Fork Skykomish local population peaked at over 530 in 2002 (USFWS 2004, Vol. 1, p. 103), but have recently declined to just over 240 in 2005 and 2006 (WDFW 2007, p. 17). This is one of two local populations in the core area (the other is South Fork Skykomish River) that support more than 100 adults, which minimizes the deleterious effects of inbreeding. The Troublesome Creek population is mainly a resident population with few migratory fish. Although adult abundance is unknown in this local population, it is probably stable due to intact habitat conditions. The Salmon Creek local population likely has fewer than 100 adults. Although spawning and early rearing habitat in the Salmon Creek area is in good to excellent condition, this local population is at risk of inbreeding depression because of the low number of adults. Monitoring of the South Fork Skykomish local population indicates increasing numbers of adult migrants. This local population recently exceeded 100 adults (Jackson, in litt. 2004) and is not considered at risk of inbreeding depression. Fishing is allowed in this system.

Productivity

Long-term redd counts for the North Fork Skykomish local population indicate increasing population trends. Productivity of the Troublesome Creek and Salmon Creek local populations is unknown but presumed stable, as the available spawning and early rearing habitats are considered to be in good to excellent condition. In the South Fork Skykomish local population, new spawning and rearing areas are being colonized, resulting in increasing numbers of spawners. Sampling of the North Fork and South Fork Skykomish local population areas indicates the overall productivity of bull trout in the Snohomish-Skykomish core area is increasing.

Connectivity

Migratory bull trout occur in three of the four local populations in the Snohomish-Skykomish core area (North Fork Skykomish, Salmon Creek, and South Fork Skykomish). The lack of connectivity with the Troublesome Creek local population is a natural condition. The connectivity between the other three local populations diminishes the risk of extirpation of the bull trout in the core area from habitat isolation and fragmentation.

Changes in Environmental Conditions and Population Status

Since the bull trout listing, Federal actions occurring in the Snohomish-Skykomish core area have caused harm to, or harassment of, bull trout. These actions include statewide Federal restoration programs that include riparian restoration, replacement of fish passage barriers, and fish habitat improvement projects; federally funded transportation projects involving repair and protection of roads and bridges; and section 10(a)(1)(B) permits for Habitat Conservation Plans addressing forest management practices. Capture and handling during implementation of section 6 and section 10(a)(1)(A) permits have directly affected bull trout in the Snohomish-Skykomish core area.

The number of non-Federal actions occurring in the Snohomish-Skykomish core area since the bull trout listing is unknown. However, activities conducted on a regular basis, such as emergency flood control, development, and infrastructure maintenance, affect riparian and instream habitat and probably negatively affect bull trout.

Threats

Threats to bull trout in the Snohomish-Skykomish core area include:

- Loss of habitat that can provide thermal and high-flow refuge. Armoring the riparian areas results in the loss of natural river functions.
    - Bank armoring to protect homes, towns, and roads built in the rivers natural channel migration zones results in the river's inability to develop side- and off-channel habitat that bull trout need for survival.
    - Bank armoring is also associated with reduced riparian vegetation and shading, which eliminates prey sources and thermal refuge for bull trout.
- Degraded habitat conditions from timber harvests and associated activities, including roads, sedimentation, and fertilization, especially in the upper watershed, where spawning occurs.
- Blocked fish passage, altered stream morphology, and degraded water quality in the lower watershed resulting from agricultural and livestock practices.
- Injury and/or mortality from illegal harvest or incidental hooking/netting, which may occur where recreational fishing is allowed by the Washington Department of Fish and Wildlife.
- Degraded water quality from municipal and industrial effluent discharges and development.
- Loss of nearshore foraging habitat and prey from continual development along riparian areas, especially from residential, commercial, and transportation construction, which usually substantiate the need for bank armoring to protect the river's natural migratory process.

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Lower Skagit Core Area

The Lower Skagit core area comprises the Skagit basin downstream of Seattle City Light's Diablo Dam, including the mainstem Skagit River and the Cascade, Sauk, Suiattle, White Chuck, and Baker River including the lake systems (Baker Lake and Lake Shannon) upstream of upper and lower Baker Dams.

Bull trout, which occur throughout the Lower Skagit core area, include fluvial, adfluvial, resident, and anadromous life history forms. Resident life history forms, found in several locations in the core area, often occur with migratory life history forms. Adfluvial bull trout occur in Baker, Shannon, and Gorge Lakes. Fluvial bull trout forage and overwinter in the larger pools of the upper portion of the mainstem Skagit River and, to a lesser degree, in the Sauk River (Kraemer 2003; WDFW et al. 1997).

Many bull trout extensively use the lower estuary and nearshore marine areas for extended rearing and subadult and adult foraging. Key spawning and early rearing habitat, found in the upper portion of much of the basin, is generally on federally protected lands, including North Cascades National Park, North Cascades Recreation Area, Glacier Peak Wilderness, and Henry M. Jackson Wilderness Area.

The status of the bull trout core area population is based on four key elements necessary for long-term viability: 1) number and distribution of local populations, 2) adult abundance, 3) productivity, and 4) connectivity (USFWS 2004).

Number and Distribution of Local Populations

Nineteen local populations were identified in the draft recovery plan (USFWS 2004) 1) Bacon Creek, 2) Baker Lake, 3) Buck Creek, 4) Cascade River, 5) Downey Creek, 6) Forks of Sauk River, 7) Goodell Creek, 8) Illabot Creek, 9) Lime Creek, 10) Lower White Chuck River, 11) Milk Creek, 12) Newhalem Creek, 13) South Fork Cascade River, 14) Straight Creek, 15) Sulphur Creek, 16) Tenas Creek, 17) Upper South Fork Sauk River, 18) Upper Suiattle River, and 19) Upper White Chuck River. Although initially identified as potential local populations in the draft recovery plan (USFWS 2004), Stetattle Creek and Sulphur Creek (Lake Shannon), each now meets the definition of local population based on subsequent observations of juvenile bull trout and prespawn migratory adult bull trout (R2 Resource Consultants and Puget Sound Energy 2005; Shannon, in litt. 2004). With 21 local populations, the bull trout in the Lower Skagit core area is at diminished risk of extirpation and adverse effects from random naturally- occurring events (see "Life History").

Adult Abundance

The Lower Skagit core area, with a spawning population of migratory bull trout that numbers in the thousands, is probably the largest population in Washington (Kraemer 2001). Consequently, the bull trout population in this core area is not considered at risk from genetic drift.

The majority of local populations in the core area include 100 adults or more; therefore, they are at a diminished risk of extirpation. However, some local populations probably have fewer than 100 adults and may be at risk from inbreeding depression. There is some risk of extirpation of the following local populations due to their lower numbers of adults; however, other factors, such as stable or increasing population trends may reduce this risk. Fewer than 100 migratory adults and a limited number of resident fish use the Forks of the Sauk River; however, the migratory component appears abundant and is increasing (Kraemer 2003). Fewer than 100 adults probably occur in Tenas Creek, but this local population is presumed to be increasing. The Straight Creek local population includes fewer than 100 migratory adults and an unknown number of resident fish (Kraemer 2001), but the migratory component appears stable. The Lime Creek local population probably has fewer than 100 migratory adults, but resident and migratory components are considered abundant. The South Fork Cascade River local population probably has fewer than 100 migratory adults (Kraemer 2001); however, resident and migratory components are considered stable. Based on recent observations, the Sulphur Creek local population in the Lake Shannon system also has fewer than 100 adults (R2 Resource Consultants and Puget Sound Energy 2006). Prior to 2004, Goodell Creek supported more than 100 adult spawners. In October 2003, a large landslide in Goodell Creek blocked access to the majority of spawning habitat for migratory bull trout in the Goodell Creek local population. Adult counts of migratory bull trout in 2004 and 2005 have been fewer than 100 individuals (Downen 2006) in this local population. In the Baker Lake local population, annual peak counts of 85 adults have been recorded between 2001 and 2005 (R2 Resource Consultants and Puget Sound Energy 2006). Since the most upstream accessible habitat was not surveyed in these efforts, and bull trout typically spawn as far upstream as they can within a stream system, this would suggest that on average there may be at least 100 adults in this local population. Total adult abundances in Newhalem and Stettatle Creek local populations are unknown.

Productivity

Long-term redd counts in the index areas of the Lower Skagit core area generally indicate stable to increasing population trends (USFWS 2004). Therefore, this core area is not considered at risk of extirpation at this time. Recent declines in redd counts may indicate a potential change to this long-term trend (Downen 2006). Redd counts conducted by WDFW between 2002 and

2005 show a significant downward trend in Bacon, Goodell, and Illabot Creeks, and the Sauk River. However, Downey Creek had a significant increase in the reported redd counts between these years. The reason for these changes is unknown.

Connectivity

The presence of migratory bull trout in most of the local populations indicates the bull trout in the Lower Skagit core area has a diminished risk of extirpation from habitat isolation and fragmentation. However, the lack of connectivity of the Baker Lake and Sulphur Creek local populations in the Baker River system and Stetattle Creek local population in the Gorge Lake system with other local populations in the core area is a concern with respect to long-term persistence, life history expression, and refounding. In addition, there is currently only partial connectivity within the Baker Lake system, with no upstream passage for adults within Lake Shannon at upper Baker Dam.

Changes in Environmental Conditions and Population Status

Since the bull trout listing, Federal actions occurring in the Lower Skagit core area have caused harm to, or harassment of, bull trout. These actions include statewide Federal restoration programs that include riparian restoration, replacement of fish passage barriers, and fish habitat improvement projects; federally funded transportation projects involving repair and protection of roads and bridges; and section 10(a)(1)(B) permits for Habitat Conservation Plans addressing forest management practices. Capture and handling, and indirect mortality, during implementation of section 6 and section 10(a)(1)(A) permits have negatively directly affected bull trout in the Lower Skagit core area.

The number of non-Federal actions occurring in the Lower Skagit core area since the bull trout listing is unknown. Activities conducted on a regular basis, such as emergency flood control, development, and infrastructure maintenance, affect riparian and instream habitat and probably have negatively affected bull trout and parts of their forage base.

Threats

Threats to bull trout in the Lower Skagit core area include:

- Gorge and Baker Dams restrict connectivity of the Stetattle Creek, Baker Lake, and Sulphur Creek (Lake Shannon) local populations with the majority of other local populations in the core area due to impaired fish passage.
- Operations of the Lower Baker Dam occasionally have significantly affected water quantity in the lower Baker and Skagit Rivers.
- Agricultural practices, residential development, and the transportation network, with related stream channel and bank modifications, have caused the loss and degradation of foraging, migration, and overwintering habitats in mainstem reaches of the major forks and in a number of the tributaries.

- Estuarine nearshore foraging habitats have been, and continue to be, negatively affected by agricultural practices and development activities.

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APPENDIX D: Sediment Analysis Framework (2010)

Appendix D: Sediment Analysis Framework (2010)

DETERMINING EFFECTS FOR SECTION 7 CONSULTATIONS

There are numerous factors that can influence project-specific sediment effects on bull trout and other salmonids. These factors include the concentration and duration of sediment input, existing sediment conditions, stream conditions (velocity, depth, etc.) during construction, weather or climate conditions (precipitation, wind, etc.), fish presence or absence (bull trout plus prey species), and best management practice effectiveness. Many of these factors are unknown.

Newcombe and Jensen (1996) and Anderson et al. (1996) provide the basis for analyzing sediment effects to bull trout and other salmonids and their habitat. Newcombe and Jensen (1996) conducted a literature review of pertinent documents on sediment effects to salmonids and nonsalmonids. They developed a model that calculated the severity of ill effect (SEV) to fish based on the suspended sediment dose (exposure) and concentration. No data on bull trout were used in this analysis. Anderson et al. (1996), using the methods used by Newcombe and Jensen (1996), developed a model to estimate sediment impacts to salmonid habitat.

A 15-point scale was developed by Newcombe and Jensen (1996, p. 694) to qualitatively rank the effects of sediment on fish (Table 1). Using a similar 15-point scale, Anderson et al. (1996) ranked the effects of sediment on fish habitat (Table 2).

We analyzed the effects on different bull trout life history stages to determine when adverse effects of project-related sediment would occur. Table 3 shows the different ESA effect calls for bull trout based on severity of ill effect.

Table 1 – Scale of the severity (SEV) of ill effects associated with excess suspended sediment on salmonids.

SEV	Description of Effect
	Nil effect
0	No behavioral effects
	Behavioral effects
1	Alarm reaction
2	Abandonment of cover
3	Avoidance response
	Sublethal effects
4	Short-term reduction in feeding rates; short-term reduction in feeding success
5	Minor physiological stress; increase in rate of coughing; increased respiration rate
6	Moderate physiological stress
7	Moderate habitat degradation; impaired homing
8	Indications of major physiological stress; long-term reduction in feeding rate; long-term reduction in feeding success; poor condition
	Lethal and paralethal effects
9	Reduced growth rate; delayed hatching; reduced fish density
10	0-20% mortality; increased predation; moderate to severe habitat degradation
11	> 20 – 40% mortality
12	> 40 – 60% mortality
13	> 60 – 80% mortality
14	> 80 – 100% mortality

The effect determination for a proposed action should consider all SEV values resulting from the action because sediment affects individual fish differently depending on life history stage and site-specific factors. For juvenile bull trout, an SEV of 5 is likely to warrant a "likely to adversely affect" (LAA) determination. However, abandonment of cover (SEV 2), or an avoidance response (SEV 3), may result in increased predation risk and mortality if habitat features are limiting in the project's stream reach. Therefore, a LAA determination may be warranted at an SEV 2 or 3 level in certain situations. For subadult and adult bull trout, however, abandonment of cover and avoidance may not be as important. A higher SEV score is more appropriate for adverse effects to subadult and adult bull trout. In all situations, we assume that SEV scores associated with adverse effects are also sufficient to represent a likelihood of harm or harass2.

Table 2 – Scale of the severity (SEV) of ill effects associated with excess suspended sediment on salmonid habitat.

SEV	Description of Effect
3	Measured change in habitat preference
7	Moderate habitat degradation – measured by a change in invertebrate community
10	Moderately severe habitat degradation – defined by measurable reduction in the productivity of habitat for extended period (months) or over a large area (square kilometers).
12	Severe habitat degradation – measured by long-term (years) alterations in the ability of existing habitats to support fish or invertebrates.
14	Catastrophic or total destruction of habitat in the receiving environment.

When evaluating impacts to habitat as a surrogate for species effects, adverse effects may be anticipated when there is a notable reduction in abundance of aquatic invertebrates, and an alteration in their community structure. These effects represent a reduction in food for bull trout and other salmonids, and correspond to an SEV of 7 – moderate habitat degradation.

Newcombe and Jensen (1996) used six data groups to conduct their analysis. These groups were 1) juvenile and adult salmonids (Figure 1), 2) adult salmonids (Figure 2), 3) juvenile salmonids (Figure 3), 4) eggs and larvae of salmonids and non-salmonids (Figure 4), 5) adult estuarine nonsalmonids (no figure provided), and 6) adult freshwater nonsalmonids (no figure provided). No explanation was provided for why juvenile and adult salmonids were combined for group 1. As juveniles are more adapted to turbid water (Newcombe 1994, p. 5), their SEV levels are generally lower than for adult salmonids given the same concentration and duration of sediment (Figures 1-3).

2 Harm and harass in this context refers to the FWS's regulatory definition at 50 CFR 17.3. E.g., Harm means "an act which actually kills or injures wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavior patterns, including breeding, feeding, or sheltering."

Table 3 – ESA Effect calls for different bull trout life stages in relation to the duration of effect and severity of ill effect. Effect calls for habitat, specifically, are provided to assist with analysis of effects to individual bull trout.		
	SEV	**ESA Effect Call**
Egg/alevin	1 to 4	Not applicable - alevins are still in gravel and are not feeding.
	5 to 14	LAA - any stress to egg/alevin reduces survival
Juvenile	1 to 4	NLAA
	5 to 14	LAA
Subadult and Adult	1 to 5	NLAA
	6 to 14	LAA
Habitat	1 to 6	NLAA
	7 to 14	LAA due to indirect effects to bull trout

The figures of Newcombe and Jensen (1996) have been modified in this document. In each figure, values (in mg/L) are provided for each duration to determine when adverse effects would occur. Specific values are also given for when harm would be likely to occur. For example:

> Figure 1 – This figure is for both juveniles and adults. From Table 2, bull trout are "likely to be adversely affected" given an SEV of 5. On Figure 1, a sediment concentration of 99 mg/L for one hour is anticipated to be the maximum concentration for an SEV of 4. At 100 mg/L, an SEV of 5 occurs. In addition, one hour of exposure to 5,760 mg/L is the maximum for an SEV of 7. Exposure to 5,761 mg/L for one hour would warrant an SEV of 8. This would be the threshold between harassment and harm. An SEV of 7 would be harassment, and an SEV of 8 would be considered harm.

The following provides some guidance on use of the figures.

Definitions from Newcombe and Jensen (1996, p. 696). These definitions are provided for consultations that may have impacts to bull trout prey such as Chinook and coho salmon.

> Eggs and larvae – eggs, and recently hatched fish, including yolk-sac fry, that have not passed through final metamorphosis.
>
> Juveniles – fry, parr, and smolts that have passed through larval metamorphosis but are sexually immature.
>
> Adults – mature fish.

Bull trout use:

Newcombe and Jensen (1996) conducted their analysis for freshwater, therefore the use of the figures within this document in marine waters should be used with caution.

Figure 1 – Juvenile and Adult Salmonids. This figure should be used in foraging, migration and overwintering (FMO) areas. In FMO areas, downstream of local populations, both subadult and adult bull trout may be found.

Figure 2 – Adult Salmonids. This figure will not be used very often for bull trout. There may be circumstances, downstream of local population spawning areas that may have just adults, but usually this would not be the case. Justification for use of this figure should be stated in your consultation.

Figure 3 – Juvenile Salmonids. This figure should be used in local population spawning and rearing areas outside of the spawning period. During this time, only juveniles and sub-adults should be found in the area. Adults would migrate to larger stream systems or to marine water. If the construction of the project would occur during spawning, then Figure 1 should be used.

Figure 4 – Eggs and Alevins. This figure should be used if eggs or alevins are expected to be in the project area during construction.

Figure 5 – Habitat. This figure should be used for all projects to determine whether alterations to the habitat may occur from the project.

Background and Environmental Baseline

In determining the overall impact of a project on bull trout, and to specifically understand whether increased sediment may adversely affect bull trout, a thorough review of the environmental baseline and limiting factors in the stream and watershed is needed. The following websites and documents will help provide this information.

1. Washington State Conservation Commission's Limiting Factors Analysis. A limiting factors analysis has been conducted on watersheds within the State of Washington. Limiting factors are defined as "conditions that limit the ability of habitat to fully sustain populations of salmon, including all species of the family Salmonidae." These documents will provide information on the current condition of the individual watersheds within the State of Washington. The limiting factors website is http://salmon.scc.wa.gov. Copies of the limiting factors analysis can be found at the Western Washington Fish and Wildlife Library.

2. Washington Department of Fish and Wildlife's (1998) Salmonid Stock Inventory (SaSI). The Washington Department of Fish and Wildlife (WDFW) inventoried bull trout and Dolly Varden (*S. malma*) stock status throughout the State. The intent of the inventory is to help identify available information and to guide future restoration

planning and implementation. SaSI defines the stock within the watershed, life history forms, status and factors affecting production. Spawning distribution and timing for different life stages are provided (migration, spawning, etc.), if known. SaSi documents can be found at http://wdfw.wa.gov/fish/sasi/index.htm.

3. U.S. Fish and Wildlife Service's (USFWS 1998a) Matrix of Diagnostics/Pathways and Indicators (MPI). The MPI was designed to facilitate and standardize determination of project effects on bull trout. The MPI provides a consistent, logical line of reasoning to aid in determining when and where adverse effects occur and why they occur. The MPI provides levels or values for different habitat indicators to assist the biologist in determining the level of effects or impacts to bull trout from a project and how these impacts may cumulatively change habitat within the watershed.

4. Individual Watershed Resources. Other resources may be available within a watershed that will provide information on habitat, fish species, and recovery and restoration activities being conducted. The action agency may cite a publication or identify a local watershed group within the Biological Assessment or Biological Evaluation. These local groups provide valuable information specific to the watershed.

5. Washington State Department of Ecology (WDOE) - The WDOE has long- and short-term water quality data for different streams within the State. Data can be found at http://www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html. Clicking on a stream or entering a stream name will provide information on current and past water quality data (when you get to this website, scroll down to the Washington map). This information will be useful for determining the specific turbidity/suspended sediment relationship for that stream (more information below).

6. Washington State Department of Ecology (WDOE) - The WDOE has also been collecting benthic macroinvertebrates and physical habitat data to describe conditions under natural and anthropogenic disturbed areas. Data can be found at http://www.ecy.wa.gov/programs/eap/fw_benth/index.htm. You can access monitoring sites at the bottom of the website.

7. U.S. Forest Service, Watershed Analysis Documents - The U.S. Forest Service (USFS) is required by the Record of Decision for Amendments to the USFS and Bureau of Land Management Planning Documents within the Range of the Northern Spotted Owl to conduct a watershed analysis for watersheds located on FS lands. The watershed analysis determines the existing condition of the watershed and makes recommendations for future projects that move the landscape towards desired conditions. Watershed analysis documents are available from individual National Forests or from the Forest Plan Division.

8. U.S. Fish and Wildlife Service - Bull Trout Recovery Plans and Critical Habitat Designations. The draft Bull Trout Recovery Plan for the Columbia River Distinct Population Segment (DPS) (also the Jarbidge River and the St. Mary-Belly River DPS) and the proposed and final critical habitat designations provide current species status,

habitat requirements, and limiting factors for bull trout within specific individual recovery units. These documents are available from the Endangered Species Division as well as the Service's web page (www.fws.gov).

These documents and websites provide baseline and background information on stream and watershed conditions. This information is critical to determining project-specific sediment impacts to the aquatic system. The baseline or background levels need to be analyzed with respect to the limiting factors within the watershed.

Consultation Sediment Analysis

The analysis in this section only applies to construction-related physiological and behavioral impacts, and the direct effects of fine sediment on current habitat conditions. Longer-term effects to habitat from project-induced channel adjustments, post-construction inputs of coarse sediment, and secondary fine sediment effects due to re-mobilization of sediment during the following runoff season, are not included in the quantitative part of this effects determination. Those aspects are only considered qualitatively.

The background or baseline sediment conditions within the project area or watershed will help to determine whether the project will have an adverse effect on bull trout. The following method should be followed to assist in reviewing effects determinations and quantifying take in biological opinions.

1) Determine what life stage(s) of bull trout will be affected by sedimentation from the project. Life history stages include eggs and alevins, juveniles, and sub-adults and adults. If projects adhere to approved work timing windows, very few should be constructed during periods when eggs and alevins are in the gravels. However, streambed or bank adjustments may occur later in time and result in increased sedimentation during the time of the year when eggs and alevins may be in the gravels and thus affected by the project.

2) Table 4 provides concentrations, durations, and SEV levels for different projects. This table will help in analyzing similar projects and to determine sediment level impacts associated with that type of project. Based on what life history stage is in the project area and what SEV levels may result from the project, a determination may be made on effects to bull trout. (Table 4 located on the Q drive: Q:\linked Literature Materials\Species & Issues & BO Templates with RefMan\Sediment Issue Paper)

3) Once a "likely to adversely affect" determination has been made for a project, the figures in Newcombe and Jensen (1996) or Anderson et al. (1996) are used to determine the concentration (mg/L) at which adverse effects3 and "take" will occur (see Figures 1-5). For example, if a project is located in FMO habitat, Figure 1 would be used to determine the concentrations at which adverse effects will occur. Since Figure 1 is used for both

3 For the remainder of the document, references to "adverse effects" also refer to harm and harass under 50 CFR 17.3.

adults and juveniles, an SEV of 5 (for juveniles) is used (see Table 2). For (a.) the level when instantaneous adverse effects occur, find the SEV level of 5 in the one hour column. The corresponding concentration is the instantaneous value where adverse effects occur. In this example, it is 148 mg/L. For (b), (c), and (d), adverse effects will occur when sediment concentrations exceed SEV 4 levels. The exact concentrations for this have been provided. For each category, find the SEV 4 levels and the corresponding concentration levels are the values used.

For impacts to individual bull trout, adverse effects would be anticipated in the following situations:

a. Any time sediment concentrations exceed 148 mg/L over background.
b. When sediment concentrations exceed 99 mg/L over background for more than one hour continuously.
c. When sediment concentrations exceed 40 mg/L over background for more than three hours cumulatively.
d. When sediment concentrations exceeded 20 mg/L over background for over seven hours cumulatively.

For habitat effects, use Figure 5 and the same procedure as above for individual bull trout. For example, adverse effects would be expected to occur in the following situations:

a. Any time sediment concentrations exceed 1,097 mg/L over background.
b. When sediment concentrations exceed 885 mg/L over background for more than one hour continuously.
c. When sediment concentrations exceed 345 mg/L over background for more than three hours cumulatively.
d. When sediment concentrations exceeded 167 mg/L over background for over seven hours cumulatively.

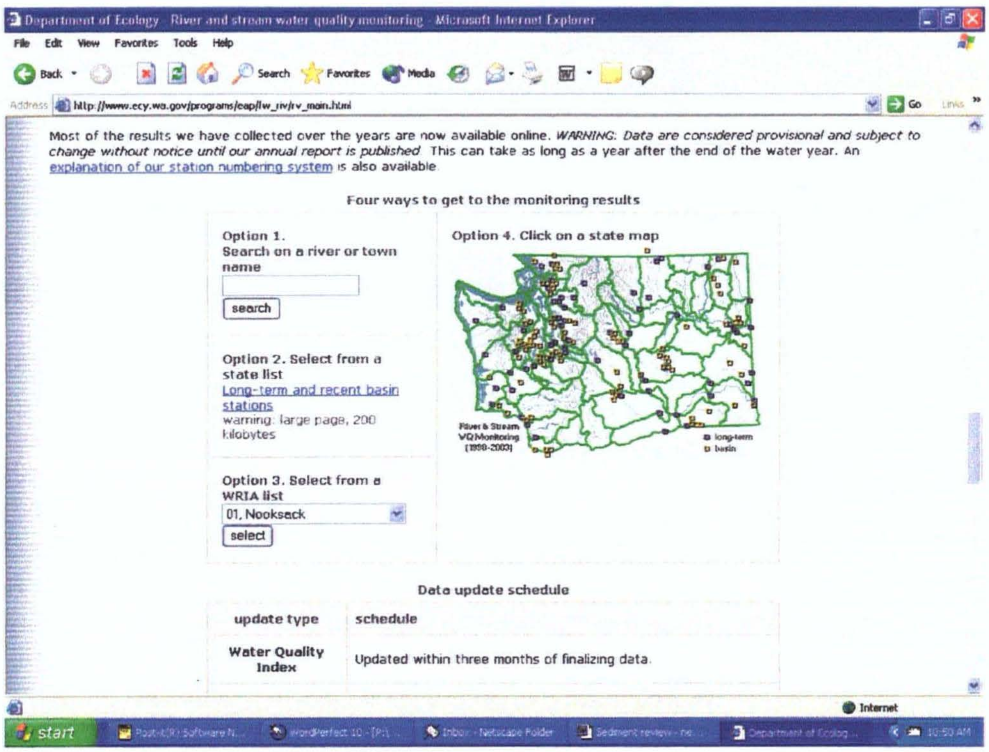
4) Because sediment sampling for concentration (mg/L) is labor intensive, many applicants prefer to monitor turbidity as a surrogate. To do this, the sediment concentration at which adverse effects to the species and/or habitat occurs is converted to NTUs. Two methods, regression analysis and turbidity to suspended solid ratio, are available for this conversion. The regression analysis method should be used first. If not enough data are available then the turbidity to suspended solid ratio method should be used.

   a. Data – as described above in Background and Environmental Baseline, an attempt should be made to find turbidity and suspended solid information from the project area, action area, or the stream in which the project is being constructed. This information may be available from the Tribes, watershed monitoring groups, etc. Try to obtain information for the months in-water construction will occur, which is usually during the fish timing window (in most cases, July through September).

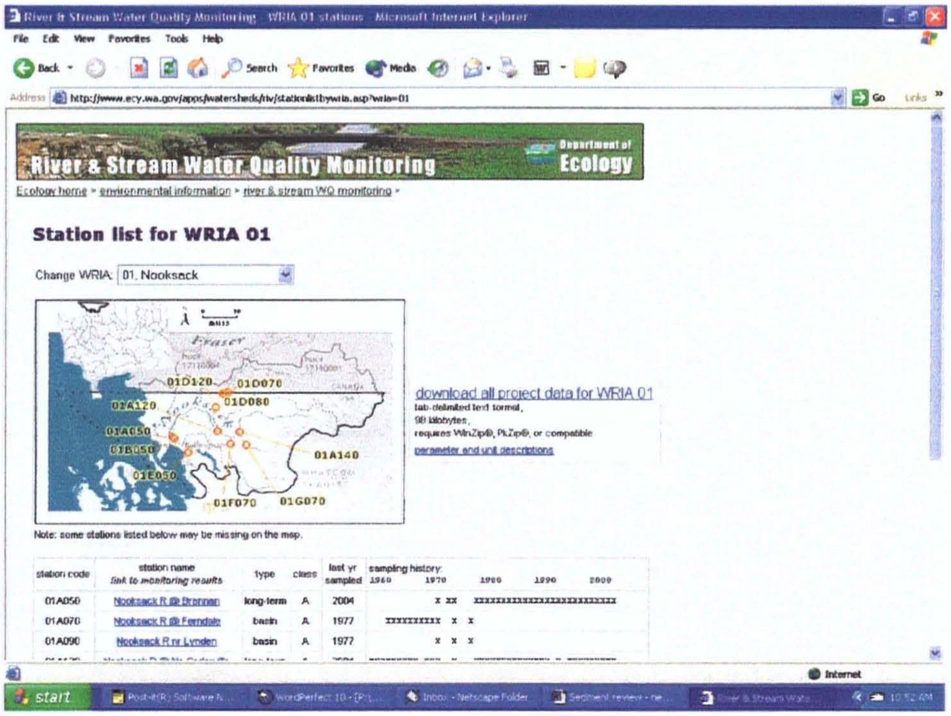
If you are unable to find any data for the action area, use the WDOE water quality monitoring data. The following are the steps you need to go through to locate the information on the web and how to download the data:

i. Go to the WDOE webpage (http://www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html).

ii. When you get to the website, the page will state "River and Stream Water Quality Monitoring." If you scroll down the page, you will see the following text and map.



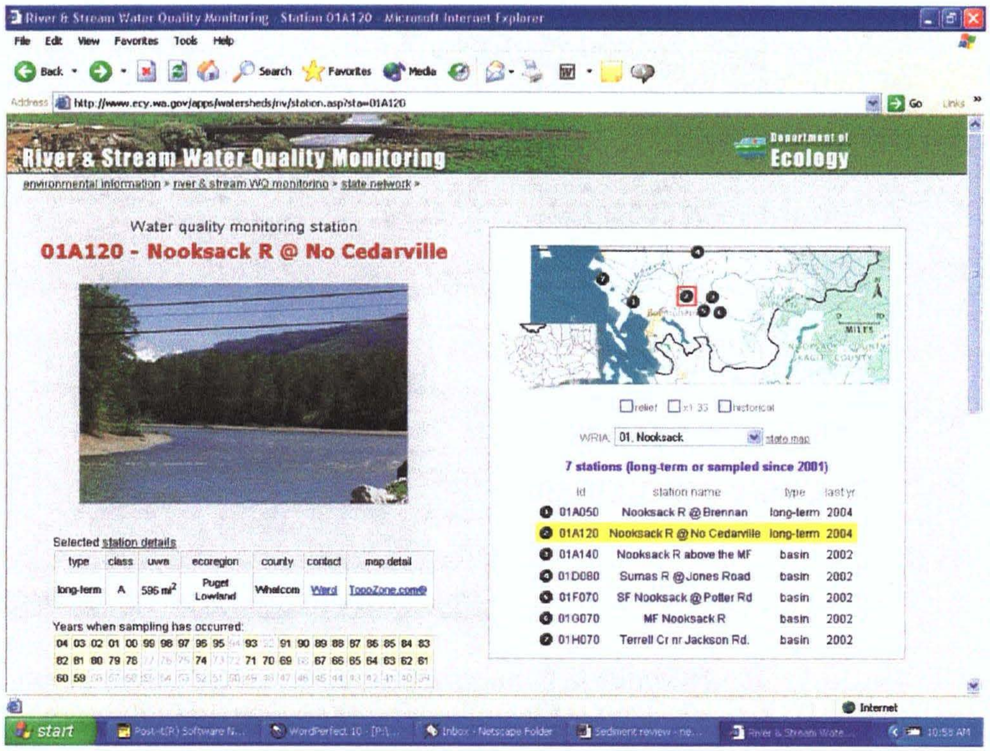
iii. The map shows all the water quality monitoring stations in Washington. You can click on a watershed, or go to Option 3, click on the down arrow and find your watershed. You will then get the following webpage. This is an example for the Nooksack River.



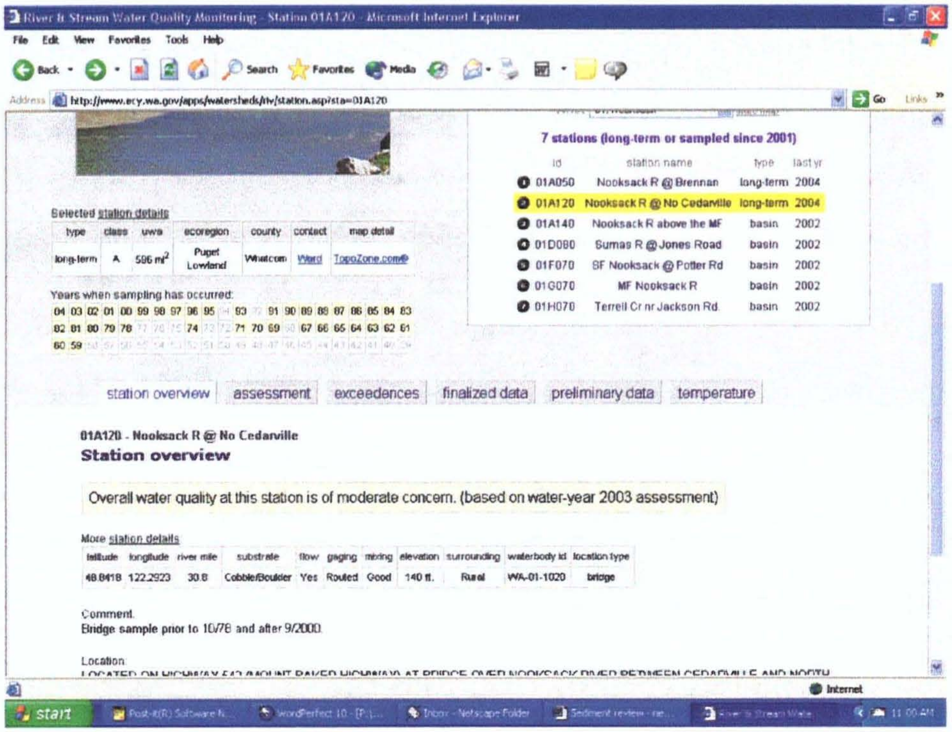
iv. This webpage shows you all the monitoring stations in this watershed. Scrolling down a little on the webpage, you get a list of the monitoring stations and the years that data were collected. The more years in which data were collected the better; however, you want to pick the monitoring station closest to the project site. If a project is located on a tributary, do not use data from the main river in the watershed. Find a monitoring station on a tributary and use that data. **Justification for the use of the data needs to be made in the BO.** The following language was used in the Anthracite Creek Bridge Scour BO. Changes to this paragraph to represent regression analysis are not italicized.

"*The guidance of Newcombe and Jensen (1996) requires a measurement of the existing suspended sediment concentration levels (mg/L) and duration of time that sediment impacts would occur. The Service used data available on the Washington Department of Ecology (WDOE) website to determine a ratio of turbidity (NTU) to suspended solids (mg/L)*(website to find the correlation between turbidity and suspended solids) *in Anthracite Creek. No water quality data was available for Anthracite Creek, so the Service used water quality monitoring data from a different tributary within the Snohomish River watershed. Patterson Creek, which is a tributary to the Snoqualmie River, was used to determine the ratio of turbidity to suspended solids* (correlation between turbidity and suspended solids). *The Service believes that Patterson Creek would have very comparable water quality data as Anthracite Creek. The turbidity to suspended solid ratio for Patterson Creek is 1:2.4 during the proposed months of construction (July through September).*" Delete the last sentence for regression analysis or put in the equation used for analysis and the R^2.

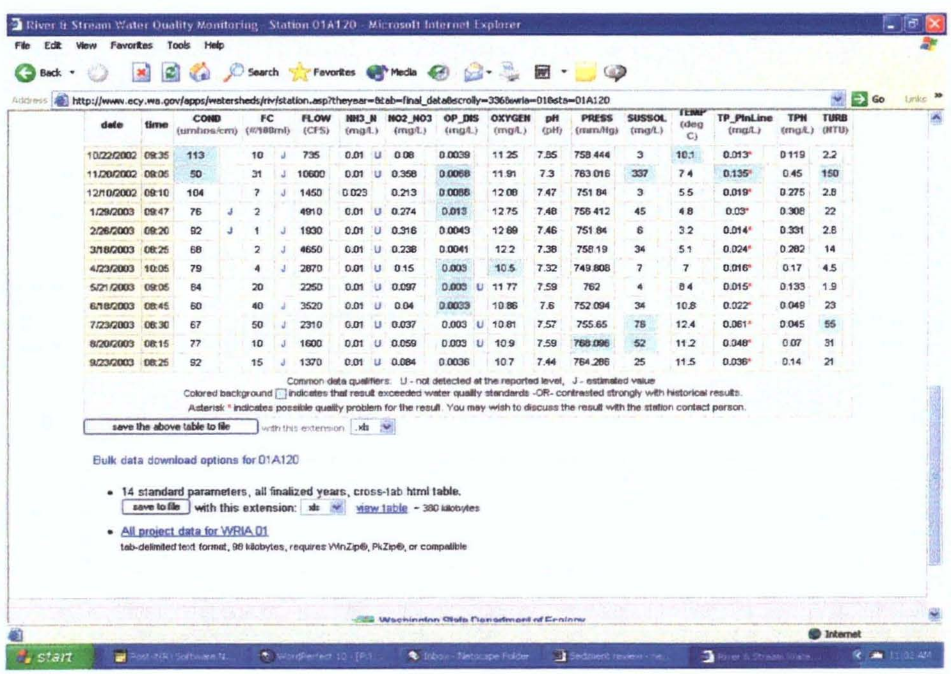
v. When you select the monitoring station, the following webpage appears. This monitoring station is on the Nooksack River at North Cedarville.



vi. Moving down the webpage, you find the following. The page shows the years data were collected and 4 to 6 tabs that provide different information. Click on the finalized data tab.



vii. Selecting the finalized data, a new page comes up; scrolling down that page you see the following. The top part of the page shows the finalized data for the most recent year data were collected. Below the data is a box that says "Bulk data download options..." Click on the "save to file" button for the 14 standardized data parameters. Follow the instructions to save this file. This saves all the data from that monitoring station so the regression analysis can be conducted.



viii. Open Excel and open the file that was just downloaded. Verify that all data appear to be available. After you have worked with these files, you will get an idea if something appears wrong. If the data looks like something is wrong, verify it by comparing the data to the finalized data on the webpage (look at each year's finalized data). After the file is open, delete all columns except the date, sussol (mg/L) and turb (NTU).

ix. Next delete the rows that do not need to be included. Only save the months in which the project will be constructed. For example, if work will be conducted during the work timing window of July 15 through August 31, delete all rows except those that contain data for July and August. The data consist of one data collection point each month. In addition, delete any values that have a "U" or "J" in the column to the right of the NTU value. This data may not be accurate; data may not be detectable at reported level or is an estimated value. The blue cells indicate the value exceeds water quality standards or contrasted strongly with historical results.

x. After deleting the unnecessary columns and rows, your data should contain 5 columns. You can now delete the columns to the right of the values. This will give you 3 columns. The first being the date, the second column contains the suspended solid data (mg/L) and the third column the turbidity (NTU) data.

b. Regression analysis. Once you have the data reduced to the months construction will occur, you can determine the relationship between turbidity and suspended solids using regression. The following steps will provide the regression equation using the data obtained above. These steps are for Excel 2007.

i. With your mouse, highlight both columns of data (suspended solid and turbidity), but do not include the heading information.

ii. Then click on "Insert", "Scatter" and then the graph that does not have any lines on it (should be the upper left graph).

iii. The graph is placed on your Excel sheet, so move it over so you can see all the data and the graph.

iv. Now add the trendline to the graph. This is done by clicking (left button) once on any of the points on the graph. Then right click. A window pops open and click on "Add Trendline." A "Format Trendline" window appears. Make sure Linear is checked, and down on the bottom, check Display Equation on chart and Display R-squared value on chart. Click on close.

1. The X and Y data are opposite of what you want so you need to swap the values. This is done by left clicking once anywhere on the graph and then right click and click on "select data." A window pops open and you want to click on Edit. An Edit Series window appears and you want to click on the little red arrow next to Series X values. This allows you to select the data in the table. Upon clicking the red arrow, you will see the column under sussol (mg/L) being selected by a moving line around the cells. Select the data under Turb (NTU) by left clicking and holding the button down and drag all the way down to the last cell in that column. The whole column should have the moving line around all the cells. Click on the little red arrow in the Edit Series window. That will expand out the window and you will do the same for the Series Y values. Click on the red arrow next to that, then left click and hold and select all the cells in the column under Sussol (mg/L), and then click on the red arrow again. When the Edit Series window expands, click on OK, and then click on OK.

v. The equation that you want to use for your conversion from NTUs to suspended solids is now on the graph. Hopefully, your R-squared value is also high. This gives you an indication of how well your data fits the line. A one (1) is perfect. If this number is low (and a ballpark figure is less than 0.60) then you may want to consider using the ratio method to determine your conversion from NTUs to suspended solids.

   1. Outliers – sometimes there will be data that will be far outside the norm. These values can be deleted and that will help increase your R-squared value. If you are good at statistics there are ways of determining outliers. If not, you will probably just use the data as is, unless you think something is really not right, then you may want to delete those data points.

vi. Using the equation for the regression analysis, convert the sediment concentrations found for when adverse effects occur to bull trout and their habitat (number 3 above) to NTUs. For our example, let's say our NTU to suspended solid equation is: $y = 1.6632x - 0.5789$. Adverse effects would then occur at (solve for x):

For impacts to the species adverse effect would occur in the following situations:

a. Any time sediment concentrations exceed 89 NTU over background.
b. When sediment concentrations exceed 60 NTU over background for more than one hour continuously.
c. When sediment concentrations exceed 24 NTU over background for more than three hours cumulatively.

d. When sediment concentrations exceeded 12 NTU over background for over seven hours cumulatively.

For impacts to habitat

a. Any time sediment concentrations exceed 660 NTU over background.

b. When sediment concentrations exceed 532 NTU over background for more than one hour continuously.

c. When sediment concentrations exceed 208 NTU over background for more than three hours cumulatively.

d. When sediment concentrations exceeded 101 NTU over background for over seven hours cumulatively.

c. Turbidity:suspended solid ratio: To calculate the turbidity to suspended solid ratio you need to download the same data off the Ecology website as described above. Sometimes the monitoring stations have limited amount of data and by running the regression analysis it is possible to get a negative slope (an increase in turbidity results in a decrease in suspended solids). This is very unlikely to occur in a stream. Other times you have so few data points that the R^2 value shows that the correlation between suspended solid and turbidity is not very good. When R^2 values are below 0.60, determine the turbidity to suspended solid ratio. The following are the steps needed to calculate the turbidity to suspended solid ratio.

i. After you deleted all the columns and rows of data you do not need, you should have 3 columns of data. The first being the date, the second column contains the suspended solid data (mg/L) and the third column the turbidity (NTU) data.

ii. Calculate the average turbidity and suspended solid value for all data. Average the turbidity column and average the suspended solid column.

iii. Calculate the turbidity to suspended solid value for the average turbidity and average suspended solid value obtained in ii. Divide the average suspended solid value by the average turbidity value.

iv. If any outliers are identified, they should be deleted. Recalculate the turbidity:suspended solid ratio if outliers have been removed (should automatically be done when values are deleted).

vii. Using the turbidity to suspended solid ratio, convert the sediment concentrations found for when adverse effects occur to bull trout and their habitat (number 3 above) to NTUs. For our example, let's say our NTU to suspended solid ratio is 2.1. Adverse effects to the species would then occur in the following situations:

a. Any time sediment concentrations exceed 70 NTU over background.

b. When sediment concentrations exceed 47 NTU over background for more than one hour continuously.

c. When sediment concentrations exceed 19 NTU over background for more than three hours cumulatively.

d. When sediment concentrations exceeded 10 NTU over background for over seven hours cumulatively.

Adverse effects to the species through habitat impacts would occur in the following situations:

a. Any time sediment concentrations exceed 522 NTU over background.

b. When sediment concentrations exceed 421 NTU over background for more than one hour continuously.

c. When sediment concentrations exceed 164 NTU over background for more than three hours cumulatively.

d. When sediment concentrations exceeded 80 NTU over background for over seven hours cumulatively.

5) Determine how far downstream adverse effects and take will occur. There is no easy answer for determining this. Table 4 provides some sediment monitoring data for a variety of projects. These data can be used to determine the downstream extent of sediment impacts for a project. Note that in Table 4 there is not a single downstream point that can always be used because sediment conveyance and mixing characteristics are different for each stream. **An explanation of how the distance downstream was determined needs to be included in each BO.**

Figure 1 – Severity of ill effect scores for juvenile and adult salmonids. The individual boxes provide the maximum concentration for that SEV. The concentration between 4 and 5 represents the threshold for harassment, and the concentration between 7 and 8 represents the threshold for harm.

Juvenile and Adult Salmonids
Average severity of ill effect scores

Concentration (mg/L)	1	3	7	1	2	6	2	7	4	11	30
	Hours			Days			Weeks		Months		
162755	10	11	11	12	12	13	14	14	-	-	-
59874	9	10	10	11	12	12	13	13	14	-	-
22026	8	9	10	10	11	11	12	13	13	14	-
8103	8	8	9	10	10	11	11	12	13	13	14
2981	$\boxed{5760}$ 7	8	8	9	9	10	11	11	12	12	13
1097	6	$\boxed{2335}$ 7	$\boxed{1164}$ 7	8	9	9	10	10	11	12	12
403	5	6	7	$\boxed{491}$ 7	8	9	9	10	10	11	12
148	5	5	6	7	$\boxed{214}$ 7	8	8	9	10	10	11
55	$\boxed{99}$ 4	5	5	6	6	$\boxed{95}$ 7	8	8	9	9	10
20	3	$\boxed{40}$ 4	$\boxed{20}$ 4	5	6	6	$\boxed{42}$ 7	8	8	9	9
7	3	3	4	$\boxed{8}$ 4	5	6	6	$\boxed{18}$ 7	$\boxed{8}$ 7	8	9
3	2	2	3	4	$\boxed{4}$ 4	5	5	6	7	$\boxed{4}$ 7	8
1	1	2	2	3	3	$\boxed{2}$ 4	5	5	6	7	$\boxed{2}$ 7

Figure 2 - Severity of ill effect scores for adult salmonids. The individual boxes provide the maximum concentration for that SEV. The concentration between 5 and 6 represents the threshold for harassment, and the concentration between 7 and 8 represents the threshold for harm.

Adult Salmonids
Average severity of ill effect scores

Concentration (mg/L)											
162755	11	11	12	12	13	13	14	14	-	-	-
59874	10	10	11	11	12	12	13	13	14	14	-
22026	9	10	10	11	11	12	12	13	13	14	14
8103	8	9	9	10	10	11	11	12	12	13	13
2981	8	8	9	9	10	10	11	11	12	12	13
1097	$\boxed{2190}$ 7	8	8	8	9	9	10	10	11	11	12
403	6	$\boxed{1095}$ 7	$\boxed{642}$ 7	8	8	9	9	10	10	11	11
148	$\boxed{156}$ 5	6	6	$\boxed{331}$ 7	$\boxed{175}$ 7	8	8	9	9	10	10
55	5	$\boxed{78}$ 5	6	6	7	$\boxed{94}$ 7	8	8	9	9	9
20	4	4	$\boxed{46}$ 5	$\boxed{24}$ 5	6	6	$\boxed{50}$ 7	$\boxed{27}$ 7	8	8	9
7	3	4	4	5	$\boxed{12}$ 5	6	6	7	$\boxed{14}$ 7	$\boxed{8}$ 7	8
3	2	3	3	4	4	$\boxed{7}$ 5	$\boxed{4}$ 5	6	6	7	$\boxed{4}$ 7
1	2	2	3	3	4	4	5	$\boxed{2}$ 5	$\boxed{1}$ 5	6	6
	1	3	7	1	2	6	2	7	4	11	30
	Hours			Days			Weeks		Months		

Figure 3 - Severity of ill effect scores for juvenile salmonids. The individual boxes provide the maximum concentration for that SEV. The concentration between 4 and 5 represents the threshold for harassment, and the concentration between 7 and 8 represents the threshold for harm.

Juvenile Salmonids
Average severity of ill effect scores

Concentration (mg/L)											
162755	9	10	11	11	12	13	14	14	-	-	-
59874	9	9	10	11	11	12	13	14	14	-	-
22026	8	9	9	10	11	11	12	13	13	14	-
	$\boxed{13119}$										
8103	7	8	9	9	10	11	11	12	13	13	14
		$\boxed{4448}$									
2981	6	7	8	9	9	10	11	11	12	13	13
			$\boxed{1931}$								
1097	6	6	7	8	9	9	10	11	11	12	13
				$\boxed{687}$							
403	5	6	6	7	8	9	9	10	11	11	12
	$\boxed{197}$				$\boxed{254}$						
148	4	5	6	6	7	8	9	9	10	11	11
		$\boxed{67}$				$\boxed{96}$					
55	4	4	5	6	6	7	8	8	9	10	11
			$\boxed{29}$				$\boxed{36}$				
20	3	4	4	5	6	6	7	8	8	9	10
				$\boxed{10}$				$\boxed{13}$			
7	2	3	4	4	5	6	6	7	8	8	9
					$\boxed{4}$				$\boxed{5}$		
3	1	2	3	4	4	5	6	6	7	8	8
						$\boxed{1}$					
1	1	1	2	3	4	4	5	6	6	8	8
	1	3	7	1	2	6	2	7	4	11	30
	Hours			Days			Weeks		Months		

Figure 4 - Severity of ill effect scores for eggs and alevins of salmonids. The individual boxes provide the maximum concentration for that SEV. The concentration between 4 and 5 represents the threshold for both harassment and harm to eggs and alevins.

Eggs and Alevins of Salmonids
Average severity of ill effect scores

Concentration (mg/L)	Hours			Days			Weeks		Months		
	1	3	7	1	2	6	2	7	4	11	30
162755	7	9	10	11	12	13	14	-	-	-	-
59874	7	8	9	10	12	13	14	-	-	-	-
22026	7	8	9	10	11	12	13	-	-	-	-
8103	7	8	9	10	11	12	13	14	-	-	-
2981	6	7	8	10	11	12	13	14	-	-	-
1097	6	7	8	9	10	11	12	14	-	-	-
403	6	7	8	9	10	11	12	13	14	-	-
148	5	6	7	9	10	11	12	13	14	-	-
55	5	6	7	8	9	10	12	13	14	-	-
20	5	6	7	8	9	10	11	12	13	-	-
7	11 4	5	7	8	9	10	11	12	13	14	-
3	4	5	6	7	8	10	11	12	13	14	-
1	4	5	6	7	8	9	10	11	13	14	-

Figure 5 - Severity of ill effect scores for salmonid habitat. The individual boxes provide the maximum concentration for that SEV. The concentration between 6 and 7 represents the threshold for anticipating adverse effects to bull trout through habitat modifications.

Salmonid Habitat
Average severity of ill effect scores

Concentration (mg/L)											
162755	11	12	12	13	14	-	-	-	-	-	-
59874	10	11	12	12	13	14	-	-	-	-	-
22026	9	10	11	11	12	13	14	14	-	-	-
8103	8	9	10	11	11	12	13	14	14	-	-
2981	8	8	9	10	11	11	12	13	13	14	-
1097	7	7	8	9	10	10	11	12	13	13	14
	$\boxed{885}$										
403	6	7	7	8	9	10	10	11	12	12	13
		$\boxed{345}$	$\boxed{167}$								
148	5	6	6	7	8	9	9	10	11	12	12
				$\boxed{68}$							
55	4	5	6	6	7	8	9	9	10	11	11
					$\boxed{29}$						
20	3	4	5	5	6	7	8	8	9	10	11
						$\boxed{12}$					
7	2	3	4	5	5	6	7	7	8	9	10
							$\boxed{5}$				
3	2	2	3	4	5	5	6	7	8	8	9
								$\boxed{2}$			
1	1	1	2	3	4	4	5	6	7	7	8
	1	3	7	1	2	6	2	7	4	11	30
	Hours			Days			Weeks		Months		

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1. Anderson, P. G., B. R. Taylor, and G. C. Balch. 1996. Quantifying the effects of sediment release on fish and their habitats.Canadian Manuscript Report of Fisheries and Aquatic Sciences 2346.

2. Newcombe, C. P. and J. O. T. Jensen. 1996. Channel suspended sediment and fisheries: synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management 16(4): 693-727.

3. Newcombe, C. P. 1994. Suspended sediment in aquatic ecosystems: ill effects as a function of concentration and duration of exposure. Victoria, British Columbia.

Samples have been taken and analyzed from areas adjacent to known, upland sources of contamination along the lower Duwamish, including groundwater found seeping from banks along the river, and pore water trapped within sediments. At some locations this seep and pore water has been found to contain metal concentrations exceeding State of Washington acute marine water quality criteria for arsenic, copper, and zinc (Windward Environmental 2010, pp. ES-11, ES-12). Within the RABs, VOCs have also been detected in pore water. The RI Report includes tabular data to describe surface water, seep, and pore water contaminant concentrations (Windward Environmental 2010, pp. 195-200), but the authors warn against making explicit comparisons between these data and established water quality criteria for many contaminants of concern (Windward Environmental 2010, p. 188).

Contaminant Risks Associated with the Existing Baseline Conditions

Based on sediment chemistry and toxicity tests, the RI Report finds that baseline risks to most ecological receptors are "low" (Windward Environmental 2010, pp. ES-30, ES-31). No adverse effects to the benthic invertebrate community would be expected throughout much of the study area (approximately 75 percent). However, more than three dozen contaminants of concern do present a risk of adverse effects to the benthic invertebrate community throughout approximately 7 percent of the study area, including the Jorgensen Forge EAA-4 and Boeing Plant 2 DSOA, and the risk of adverse effects to these same biota is uncertain for an additional 18 percent of the study area (Windward Environmental 2010, pp. ES-12, ES-13, ES-31).

The RI Report identifies PCBs as a significant risk driver for the river otter (*Lontra canadensis*) receptor (Windward Environmental 2010, pp. ES-15, ES-30). Because of their prey preferences, which include filter-feeding crustaceans and mollusks, and because PCBs tend to bioaccumulate in fatty tissue, the EPA expects that river otters consuming a high percentage of prey from the lower Duwamish may experience exposure concentrations sufficient to result in measurable adverse effects.

The RI Report identifies PCBs, arsenic, carcinogenic PAHs, and dioxins/furans as significant human health risk drivers. The highest human health risks are associated with consumption of resident fish, crabs, and clams, with lower risks associated with activities bringing human receptors into direct contact with contaminated sediment (e.g., beach play)(Windward Environmental 2010, p. ES-30). Risk-based threshold concentrations determined for human seafood consumption scenarios, and comparisons with Puget Sound background concentrations, have been important considerations when determining required Removal Action Levels (Windward Environmental 2010, pp. ES-22 thru ES-25, ES-32).

Status of the Species in the Action Area

The action area is used seasonally by bull trout for foraging, migration, and overwintering (lower Green River FMO and Puget Sound Marine FMO). FMO habitat is important for maintaining a diversity of life history forms and for providing access to productive foraging areas (USFWS 2004, p. 49). The lower Duwamish River plays an important role as a migratory corridor linking the Green River and its tributaries to nearshore marine waters of the Puget Sound. As transitional habitat between the freshwater and saltwater environments, lowermost portions of the Duwamish River provide habitats where outmigrating juvenile salmon and in-migrating adult salmon adjust physiologically to changing surface water salinities and chemistry. The waters within the action area, including nearshore marine waters of Elliot Bay, support a prey base important to anadromous bull trout of the Puget Sound Management Unit.

Migratory bull trout use nonnatal watersheds, habitat located outside of their spawning and early rearing areas, to forage, migrate, and overwinter (Brenkman and Corbett 2003a,b in USFWS 2004). Anadromous adult and subadult bull trout are known to occur in the action area, and presumably originate from the local populations of the Puyallup River, Snohomish-Skykomish River, and Skagit River core areas. Current information, while incomplete, suggests that the Green River does not support local bull trout populations, spawning, or rearing (USFWS 2004), and suitable bull trout spawning and rearing habitats are not present in the action area.

The Puyallup River and Snohomish-Skykomish River core areas are located in relatively close proximity to the action area. The Snohomish-Skykomish River and Skagit River core areas support robust local populations, including a significant anadromous component. For these reasons, most bull trout using the lower Duwamish River and nearshore marine waters of Elliot Bay are likely to originate from any of these cores areas and local populations. Appendix C provides core area summaries for the Puyallup, Snohomish-Skykomish, and Skagit River Core Areas. Adult and subadult bull trout may occupy these waters at any time of year, but information is not available to reliably estimate the number of bull trout that may forage, migrate, and overwinter in the action area.

Historically, bull trout were reported to use the Duwamish River and lower Green River in "vast" numbers (Suckley and Cooper 1860 in USFWS 2004). In contrast, bull trout are observed infrequently in this system today. Prior to the permanent redirection of the Stuck River (lower White River) into the Puyallup River system in 1906 (Williams et al. 1975), the lower Green River system provided habitat for spawning populations of bull trout from the White River. Another factor that may have diminished the Green-Duwamish River system's value for bull trout is the loss of the Black River due to construction of the Lake Washington Ship Canal in the mid-1910's. The Black River historically connected the Lake Washington Basin and Cedar River to the Green-Duwamish River system. Creation of the ship canal and Ballard Locks lowered Lake Washington by 2.7 meters (9 ft) and completely redirected flows of the Cedar River and Lake Washington tributaries to the canal (Warner 1996). The effect of these diversions was to leave the Green-Duwamish River system with approximately one-third of its original watershed, by area (Parametrix and NRC 2000 in USFWS 2004).

More recently, bull trout have been reported on the lower Green River as far upstream as the mouth of Newaukum Creek, at approximately river mile 41, and are consistently reported in the lower Duwamish (Berge and Mavros 2001; KCDNRP and WSCC 2000; KCDNRP 2002). It is presumed that bull trout utilize the Green River up to the City of Tacoma's Headworks Diversion Dam at river mile 61, which has been a barrier to upstream migration since 1912 (KCDNRP and WSCC 2000). It is not known for certain whether the bull trout observed in the lower Green River basin are foraging individuals from other core areas, or if natural reproduction may still persist somewhere within the basin. However, based on observed behavior from other systems within the management unit, and the size of individuals typically reported, there is a strong likelihood that bull trout in the lower Green River are anadromous migrants from other core areas. Reports of historical use of tributaries in the lower Green River are rare, and there have been no recent observations (KCDNRP and WSCC 2000). Given their size and potential as a foraging area, tributaries such as Newaukum and Soos Creeks may occasionally be used by bull trout.

Bull trout occurrence in the Duwamish River has been documented several times over the past few decades. In April 1978, Dennis Moore, Hatchery Manager for the Muckleshoot Tribe, talked with three fishermen in the vicinity of North Wind Weir, river mile 7 of the Duwamish, and identified four fish as adult char (Brunner, pers comm 1999b). One adult bull trout was observed near Pier 91 in May 1998 (Brunner, pers comm 1999a). During 2000, eight subadult bull trout were captured in the Duwamish River at the head of the navigation channel, near the Turning Basin restoration site at river mile 5.3. These fish averaged 299 mm (11.8 inches) in length and were captured in August and September (Shannon, in litt. 2001 in USFWS 2004). A single subadult char (222 mm; 8.7 inches) was caught at this same site during September of 2002 (Shannon 2002). During May of 2003, a large adult bull trout (582 mm; 23 inches) was captured in the lower Duwamish River at Kellogg Island (Shannon 2003).

It is not known whether bull trout historically occupied habitats in the upper Green River basin. Various fish sampling efforts in the upper Green River (above Howard Hansen Dam) have not detected bull trout (KCDNRP and WSCC 2000). The City of Tacoma has proposed to construct a trap and haul facility at the Headworks Diversion Dam to allow fish passage to the upper watershed as part of their habitat conservation plan. Although uncertain, it is possible that a bull trout population may become established or reestablished in the upper watershed once this facility is constructed. Establishing a self-sustaining population in the Green River system would help maintain bull trout distribution within the southern portion of the Puget Sound Management Unit. The recovery team currently identifies the upper Green River, above the Headworks Diversion Dam, as a research needs area.

The action area provides FMO habitat for bull trout, plays an important role as a migratory corridor linking the Green River and its tributaries to nearshore marine waters of the Puget Sound, and supports a prey base which is important to anadromous bull trout of the Puget Sound Management Unit. The Service expects that low numbers of adult and subadult bull trout may occupy these waters at any time of year. However, information is not available to reliably estimate the number of bull trout that may forage, migrate, and/or overwinter in the action area.

Status of Critical Habitat in the Action Area

The Service's recent final rulemaking revises the previous (2005) bull trout critical habitat designation (50 FR 63898 [October 18, 2010]). This final rule took effect on November 17, 2010. The action area provides eight of the nine PCEs that define bull trout critical habitat:

(1) *Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.*

Throughout the action area the river and its floodplain are almost completely developed. Less than 2 percent of the lower Duwamish River's intertidal wetland remains intact today (KCDNRP and WSCC 2000). This loss of floodplain connectivity and wetland function contributes to low base flow conditions and elevated surface water temperatures. However, it is unclear how springs, seeps, and other groundwater sources historically contributed to water quantity and quality at this low position in the watershed.

Within the action area this PCE still functions, but is severely impaired.

(2) *Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.*

The lower Duwamish River's proper function as a migratory corridor is greatly diminished. Elevated surface water temperatures, extensive sediment and surface water contamination, loss of floodplain connectivity, altered hydrologic conditions (including low base flows), degraded riparian conditions, extensive bank hardening and channelization, loss of pool, refuge, and off-channel habitat, and a great many and wide variety of artificial overwater structures and encumberances present physical, biological, and water quality impediments to free movement and migration.

Within the action area this PCE still functions, but is severely impaired.

(3) *An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.*

Despite heavily degraded flooplain, riparian, and instream habitat conditions in the lower Duwamish River, the Green-Duwamish watershed still supports salmon and steelhead. These populations of Chinook, chum, and coho salmon, steelhead, and sea run coastal cutthroat trout, as well as other native and nonnative fishes, provide a sizable prey base for adult and subadult bull trout. However, sediments and surface water are contaminated throughout large portions of the lower Duwamish River and these present an ongoing threat to the health of the benthic invertebrate community and food web in general (Windward Environmental 2010). Sources of terrestrial prey are greatly diminished.

Within the action area this PCE still functions, but is moderately impaired.

(4) *Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks and unembedded substrates, to provide a variety of depths, gradients, velocities, and structure.*

The lower Duwamish River exhibits greatly reduced instream habitat complexity and diversity. Throughout the action area the river and its floodplain are almost completely developed. Since the late 1800s these portions of the lower Duwamish River have been the focus of a long succession of flood control, navigational, port, industrial, and other related activities (LDWG

2012b). Less than 2 percent of the lower Duwamish River's pre-development estuarine mud flat, sand flat, and intertidal wetland remains intact today (KCDNRP and WSCC 2000). The action area exhibits fragmented and heavily degraded riparian conditions, extensive bank hardening and channelization, a fairly uniform U-shaped channel, degraded substrate conditions, greatly diminished pool, refuge, and off-channel habitat, and a great many and wide variety of artificial overwater structures and encumberances. Instream habitat function and complexity is substantially diminished compared to historic conditions.

Within the action area this PCE still functions, but is severely impaired.

(5) *Water temperatures ranging from 2 to 15 °C (36 to 59 °F), with adequate thermal refugia available for temperatures that exceed the upper end of this range. Specific temperatures within this range will depend on bull trout life-history stage and form; geography; elevation; diurnal and seasonal variation; shading, such as that provided by riparian habitat; stream flow; and local groundwater influence.*

Portions of the lower Green and Duwamish Rivers are identified as waters of concern for the temperature criteria, and the lower Duwamish River frequently experiences elevated surface water temperatures during the summer months. Extremes of temperature may prevent or discourage bull trout from using and occupying habitats along the lower Duwamish River from July through September of some years.

Within the action area this PCE still functions, but is moderately impaired.

(7) *A natural hydrograph, including peak, high, low, and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.*

The hydrology of the lower Duwamish River has been substantially altered from historic conditions through diversion of the Stuck River (lower White River), Black River, and Cedar River early in the last century. The effect of these diversions was to leave the Green-Duwamish River system with only a third of its original watershed (Parametrix and NRC 2000 in USFWS 2004). Today the lower Duwamish River exhibits reduced base flows. The floodplain is almost completely developed and no doubt contributes to an altered storm hydrograph (i.e., "flashy" peak flows).

Within the action area this PCE still functions, but is moderately impaired.

(8) *Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.*

Throughout the action area the river, its floodplain, and intertidal wetlands are almost completely developed. Diversions leave the Green-Duwamish River system with only a third of its original watershed (Parametrix and NRC 2000 in USFWS 2004). This loss of floodplain connectivity, wetland function, and natural hydrology contributes to low base flow conditions and elevated surface water temperatures. Extremes of temperature may prevent or discourage bull trout from using and occupying habitats along the lower Duwamish River from July through September of some years. Sediments and surface water are contaminated throughout large portions of the lower Duwamish River and these present an ongoing threat to the health of the benthic invertebrate community and food web in general (Windward Environmental 2010). Water quantity and quality conditions are degraded throughout the action area and limit normal bull trout reproduction, growth, and survival.

Within the action area this PCE still functions, but is severely impaired.

(9) *Sufficiently low levels of occurrence of nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass); interbreeding (e.g., brook trout); or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.*

Nonnative fish known to occur in the Green-Duwamish watershed include yellow perch (*Perca flavescens*), black crappie (*Pomoxis nigromaculatus*), pumpkinseed (*Lepomis gibbosus*), brown bullhead (*Ameiurus nebulosus*), smallmouth bass (*Micropterus dolomieui*), largemouth bass (*Micropterus salmoides*), and Atlantic salmon (*Salmo salar*) escapees from commercial net-pens in the Puget Sound (KCDNRP and WSCC 2000). Adult and subadult bull trout inhabiting the action area are sufficiently large and therefore these nonnative species do not pose a threat of predation. However, nonnative fish do compete for prey resources within the action area, and existing baseline environmental conditions may advantage warm water fish and/or those species which have been found to exploit artificial overwater structures (e.g., large and smallmouth bass).

Within the action area this PCE still functions, but is moderately impaired.

Effects of Past and Contemporaneous Actions

Throughout the action area the lower Duwamish River and its floodplain are almost completely developed. Since the late 1800s these portions of the lower Duwamish River have been the focus of a long succession of flood control, navigational, port, industrial, and other related activities (LDWG 2012b). Less than 2 percent of the lower Duwamish River's pre-development estuarine mud flat, sand flat, and intertidal wetland remains intact today (KCDNRP and WSCC 2000), and hydrology has been substantially altered from historic conditions through diversion of the Stuck River (lower White River), Black River, and Cedar River. The effect of these diversions was to leave the Green-Duwamish River system with only a third of its original watershed (Parametrix and NRC 2000 in USFWS 2004).

The EPA placed the Lower Duwamish Waterway onto the National Priorities ("Superfund") List during 2001, but sources of toxic surface water and sediment contamination, and the feasibility of various source control and corrective actions, have been the focus of intensive study since the mid-1970s (LDWG 2012b). Related corrective actions began as early as the 1950s and 60s with curtailment of toxic industrial discharges and improved or replaced sewer and water treatment infrastructure. Corrective actions have continued to the present in the form of hazardous waste disposal programs, preservation and restoration of intertidal habitats, control and retrofit of CSOs and further improvements to sewer and water treatment infrastructure, and cleanup (removal and disposal) of soil, water, and sediment contamination at a number of locations along the lowermost six miles (LDWG 2012a).

The quality and amount of FMO habitat available to bull trout along the lower Duwamish River, and its proper function as a migratory corridor, are today greatly diminished. Degraded floodplain and riparian conditions, loss of instream habitat complexity and function, and impaired surface water and sediment quality may limit normal bull trout reproduction, growth, and survival in the action area. While the action area does provide seasonal foraging opportunities (e.g., during periods of juvenile salmonid outmigration), baseline environmental conditions also expose bull trout to sources of stress and the action area functions poorly as a migratory corridor transitioning between the freshwater and marine environments.

The Service has previously issued Opinions and granted incidental take for more than two dozen actions adversely affecting bull trout of the Puyallup River, Snohomish-Skykomish River, or Skagit River core areas. The Service determined that each of these actions is not likely to jeopardize the continued existence of the bull trout, and will not destroy or adversely modify designated bull trout critical habitat. Nevertheless, the combined effects of these past and contemporaneous Federal actions have resulted in short and long term adverse effects to bull trout and, in some instances, an incremental degradation of the environmental baseline.

Other past and contemporaneous actions with particular relevance include completed and on-going source control, cleanup, and remedial actions to address toxic soil, surface/groundwater, and sediment contamination. Presumably, sources of contamination are now reduced and completed actions have made some progress in lessening exposure and effects to the lower Duwamish River ecosystem.

EFFECTS OF THE ACTION

Regulations implementing the Act define the "effects of the action" as "the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action that will be added to the environmental baseline" (50 CFR Section 402.02). This section details the anticipated effects of the proposed action on the bull trout and designated bull trout critical habitat.

We expect that the proposed action will result in both direct and indirect effects to bull trout and to designated bull trout critical habitat. Some of these effects will be temporary, construction-related, and limited in both physical extent and duration. Others will be long term and/or permanent. The analysis that follows addresses these effects, as well as any potential effects associated with interrelated and interdependent actions.

The proposed action will permanently remove a large quantity of contaminated media (sediment and soils) from the lower Duwamish and adjacent uplands, will implement related source control measures to prevent re-contamination, and provide habitat enhancement and mitigation to partially offset the environmental and natural resource damages resulting from the historic and continuing releases of hazardous substances to the lower Duwamish. Accordingly, we expect that the proposed action will dramatically improve sediment and water quality conditions in these portions of the lower Duwamish River, will reduce long term contaminant exposure risks, and contribute substantially to the comprehensive Superfund Site cleanup and remediation effort. We expect that the proposed action will provide significant, measurable, long term benefits to the bull trout and designated bull trout critical habitat, resulting from improved sediment and water quality, a healthier prey base with reduced contaminant burdens, and improved overall ecological function.

The proposed action will have measurable, temporary, adverse effects to bull trout and to designated bull trout critical habitat. Construction activities will directly affect instream habitat that supports bull trout and bull trout may be present at the time of construction. The EPA and Applicants have committed to a number of conservation measures which we expect will reduce temporary impacts, including the extent and severity of temporary water quality stressors resulting from re-suspension of contaminated sediment and release of contaminated interstitial pore water. We conclude, however, that exposure of adult and subadult bull trout to construction activities is not discountable. A sub-section that follows discusses the adverse effects to bull trout and to designated bull trout critical habitat which we expect are reasonably certain to occur.

The following sub-sections discuss insignificant and discountable effects, adverse effects to bull trout individuals and habitat, and effects to the PCEs of designated bull trout critical habitat.

Insignificant and Discountable Effects (Bull Trout)

Some of the proposed action's potential effects to the bull trout are insignificant or discountable. Effects to bull trout resulting from the following items of work are considered extremely unlikely to occur (discountable), or will not be measurable or detectable (insignificant):

<u>Jorgensen Forge and EAA-4</u>

- Excavation of contaminated media and debris from the intertidal zone (+20 thru +2 MLLW).

- Removal of existing creosote-treated wood piles from the intertidal zone, accomplished with the use of a vibratory hammer, by direct pulling, cutting at the mudline, or by a combination of these methods.

- Upland disposal of contaminated media.

- Source control measures, including cleaning and decommissioning of existing stormwater conveyances and outfalls, abandonment and removal of associated structures and contaminated media, and stormwater system upgrades and improvements.

Boeing Plant 2 and DSOA

- Excavation of contaminated media and debris from the intertidal zone (+20 thru +2 MLLW).

- Controlled demolition and removal of the existing overwater structures and bulkheads associated with the Boeing 2-40s Complex, including creosote-treated wood piles and pile clusters, batter boards, concrete foundations and debris, concrete floor slabs, and associated infrastructure.

- Upland disposal of contaminated media.

- Installation and use of temporary structures placed on the channel bed, intertidal zone, and banks, including mooring piles or dolphins and an access pier or dock located along Slip-4.

- Source control measures, including cleaning and decommissioning of existing stormwater conveyances and outfalls, abandonment and removal of associated structures and contaminated media, removal of caulk and other building materials containing contaminants of concern, and construction of new stormwater treatment facilities and outfalls.

- Habitat enhancement and mitigation measures, including creation of additional shallow intertidal habitat, functional wetland and riparian plantings, and features to support Tribal fishing access.

Similarly, the following direct and indirect effects are considered extremely unlikely to occur (discountable), or will not be measurable or detectable (insignificant):

- Entrainment, stranding, and/or handling when completing work in the intertidal zone (+20 thru +2 MLLW).

- Entrainment when dredging sediments with an enclosed, environmental clambshell bucket, conventional clamshell bucket, or diver-operated hydraulic dredge.

- Effects to bull trout prey resources.

Work Completed During Low Tides

With full and successful implementation of the agreed-upon conservation measures, we expect that work completed during low tides at elevations above +2 MLLW will not disrupt normal bull trout behaviors (feeding, moving, and sheltering), and will have an insignificant effect on bull trout and their habitat. This work includes excavation of contaminated media from the intertidal zone; removal of creosote-treated wood piles, pile clusters, and other debris from the intertidal zone; and, controlled demolition and removal of overwater structures and bulkheads associated with the Boeing 2-40s Complex. The action includes conservation measures designed to minimize residuals, sloughing, and re-suspension of contaminated sediment, and the EPA and Applicants will take all measures necessary to prevent exceedances of the State of Washington's surface water quality criteria beyond the edge of the allowable mixing-zone (or compliance boundary).

Work completed during low tides at elevations above +2 MLLW will not expose bull trout to temporary stressors, and will not disrupt normal bull trout behaviors (feeding, moving, and sheltering). Work completed above +2 MLLW will not preclude use of the intertidal zone and will create measurably improved habitat conditions for bull trout and their prey, especially where habitat is restored and enhanced with placement of clean habitat mix and functional wetland and riparian plantings. With full and successful implementation of the agreed-upon conservation measures, we expect that work completed during low tides at elevations above +2 MLLW will have an insignificant effect, and/or beneficial effect, on bull trout and their habitat.

Upland Disposal of Contaminated Media

With full and successful implementation of the agreed-upon conservation measures, we expect that upland disposal of contaminated media will have no effect on bull trout or their habitat. All wastes and contaminated media will be handled, stored, transported, tested, treated, and disposed in full compliance with all applicable State and Federal requirements. These media include contaminated soils, surface and subsurface sediments, creosote-treated wood, caulk and other building materials containing contaminants of concern, and contaminated media found and removed from stormwater conveyance and treatment systems as part of the proposed source control measures. All removed creosote-treated wood and contaminated media will be disposed at permitted and approved upland disposal sites accepting hazardous (Subtitle C) or non-hazardous (Subtitle D) solid wastes, as appropriate. The action does not include in-water disposal of dredged surface or subsurface sediments. With full and successful implementation of the agreed-upon conservation measures, we expect that upland disposal of contaminated media will have no effect on bull trout or their habitat.

Temporary Structures

With full and successful implementation of the agreed-upon conservation measures, we expect that temporary structures placed on the channel bed, intertidal zone, and banks will not disrupt normal bull trout behaviors (feeding, moving, and sheltering), and will have an insignificant effect on bull trout and their habitat. This work includes: installation of mooring piles or dolphins at approximately twenty locations, each of these consisting of either a single 12- to 24-inch diameter steel pile, or a cluster of three such piles; and, installation of an access pier or dock located along Slip-4, including approximately sixteen (16) 12-inch diameter steel piles.

The EPA and Applicants have stated that they will install all steel piles with a vibratory hammer, or by direct-pushing, to the fullest extent practicable (AMEC Geomatrix 2011, pp. 7, 8). Except for the purpose of proofing piles associated with the Slip-4 access pier or dock, and determining load-bearing capacity, the EPA and Applicants will not resort to use of an impact hammer unless and until site conditions are encountered that prevent effective use of a vibratory hammer (or direct pushing). If the EPA and/or Applicants determine that impact pile driving is necessary to achieve the required substrate embeddedness and/or load-bearing capacity, they shall provide notice to the Service.

Vibratory hammers produce underwater SPLs that are substantially lower than those generated by impact hammers (Nedwell and Edwards 2002). Underwater sound produced by vibratory and impact hammers differs not only in intensity, but also in frequency and impulse energy (i.e., total energy content of the pressure wave). This may explain why no documented fish kills have been associated with the use of vibratory hammers. Most of the sound energy produced by impact hammers is concentrated at frequencies between 100 and 800 Hz, across the range thought to be most harmful to exposed aquatic organisms, while sound energy produced by vibratory hammers is concentrated between 20 and 30 Hz. In addition, SPLs produced by impact hammers rise much more rapidly than do the SPLs produced by vibratory hammers (Carlson et al. 2001; Nedwell and Edwards 2002).

The sites where temporary piles would be placed and removed with a vibratory hammer are located in a large river where currents, boat/tug and barge traffic contributes substantially to ambient levels of underwater sound. We expect that underwater SPLs produced when installing steel piles with a vibratory hammer, and when removing these piles, will not be detectable to a significant distance. Pile installation and removal with a vibratory hammer will not produce SPLs with a potential to kill or injure exposed bull trout. Furthermore, while bull trout individuals may be exposed to resulting temporary stressors (underwater sound), we expect those exposures will be low-intensity, intermittent, and therefore will not measurably affect normal bull trout behaviors (feeding, moving, and sheltering). We conclude that pile installation and removal with a vibratory hammer will have no measurable effect on bull trout individuals, their prey base, or habitat, and is therefore insignificant.

In the event that the EPA and/or Applicants find it necessary to conduct impact pile driving, either for the purpose of proofing piles or determining load-bearing capacity, they shall provide a timely notice to the Service. However, based on location within a small, "blind" channel extending off of the waterway, and assuming that the EPA and Applicant conduct the work during the approved in-water work window (August 1 to February 15; Boeing Plant 2 and DSOA) and at low tide, we expect that limited impact pile driving conducted at the location of the Slip-4 access pier or dock will not expose bull trout to injurious SPLs, or significantly disrupt normal bull trout behaviors (feeding, moving, and sheltering). The same line of reasoning may or may not hold for other locations, and therefore, the EPA and Applicants are advised that if impact pile driving is necessary at other locations, they should expect to implement a bubble curtain noise attenuation device meeting established design and performance standards.

With full and successful implementation of the agreed-upon conservation measures, we expect that temporary structures placed on the channel bed, intertidal zone, and banks will not disrupt normal bull trout behaviors (feeding, moving, and sheltering), and will have an insignificant effect on bull trout and their habitat.

Source Control Measures

With full and successful implementation of the agreed-upon conservation measures, we expect that the proposed source control measures will not disrupt normal bull trout behaviors (feeding, moving, and sheltering), and will have an insignificant effect on bull trout and their habitat. This work includes cleaning and decommissioning of existing stormwater conveyances and outfalls, abandonment and removal of associated structures and contaminated media, and removal of caulk and other building materials containing contaminants of concern. At Jorgensen Forge and EAA-4, this work will also include stormwater system upgrades and improvements, including additional treatment facilities and/or BMPs. At Boeing Plant 2 and DSOA, this work will include decommissioning all of the existing stormwater outfalls within the project area south of Building 2-10, construction of four new stormwater outfalls, and of three new stormwater treatment facilities (bioswales or functionally-equivalent BMPs).

The proposed source control measures will function to prevent re-contamination of the RABs, and will improve the efficiency and cost effectiveness of the comprehensive Lower Duwamish Waterway cleanup and remediation effort. These measures include post-construction monitoring and adaptive management, performed in coordination with ongoing monitoring required under the applicable NPDES Stormwater General Permit(s). If this monitoring identifies discharges exceeding the limits of the Stormwater General Permit, or that are deemed likely to re-contaminate the RABs, the EPA and Applicants will identify and implement additional source control measures (AMEC Geomatrix 2011, p. 8, Appendix A; Anchor QEA, in litt. 2012, pp. 3, 4).

The EPA and Boeing have already begun or completed many of the recommended source control activities, as Interim Measures (see *Description of the Proposed Action, Boeing Plant 2 and DSOA*). Source control activities that remain to be completed at Boeing Plant 2 and DSOA include decommissioning all of the existing stormwater outfalls within the project area south of Building 2-10, construction of four new stormwater outfalls, and of three new stormwater treatment facilities serving approximately 78 acres of impervious surface within redeveloped portions of the Boeing Plant 2 Facility (AMEC Geomatrix 2011, p. 8, Appendix A). The new stormwater outfalls will discharge at depths of -9 to -10 MLLW, away from the areas where EPA and Boeing propose to restore and enhance nearshore intertidal, wetland, and riparian habitat ("South Shoreline", and "Southwest Bank Shoreline Area")(AMEC Geomatrix 2011, Appendix A, p. 3). The new stormwater treatment facilities will consist of bioswales or functionally-equivalent BMPs.

We expect that post-construction, operational discharges of stormwater runoff from redeveloped portions of the Jorgensen Forge and Boeing Plant 2 facilities may measurably affect surface water quality within a discernible mixing-zone. However, we expect that the proposed stormwater system improvements will also significantly reduce the discharge of conventional industrial stormwater pollutants (solids; total and dissolved metals; etc.), and nearly or completely eliminate all contributions of contaminants of concern to the RAB. The stormwater design will not cause or contribute to measurable increases in surface water temperature, degrade thermal refugia within the action area, or impair function of the proposed nearshore intertidal, wetland, and riparian enhancements. With consideration for the baseline conditions in the action area, proposed source control and water quality treatment, and the receiving water's large size and assimilative capacity, we conclude that long term effects to surface water quality will not be measurable to any significant distance beyond the points of stormwater discharge.

With full and successful implementation of the agreed-upon conservation measures, including post-construction monitoring and adaptive management, we expect that operational discharges of stormwater runoff will not disrupt normal bull trout behaviors (feeding, moving, and sheltering), and will have an insignificant effect on bull trout and their habitat. We expect that the proposed source control measures will prevent re-contamination of the RABs and will have an insignificant effect, and/or beneficial effect, on bull trout and their habitat.

Habitat Enhancement and Mitigation Measures

At Boeing Plant 2 and DSOA, this work will include restoration and enhancement of approximately 4.8 acres of nearshore intertidal, wetland, and riparian habitat, including approximately 3,000 linear ft of shoreline, along and at the upstream and downstream limits of the cleanup area ("North Shoreline", "South Shoreline", and "Southwest Bank Shoreline Area")(AMEC Geomatrix 2011, pp. 5-7, 33). Pursuant to NRDA requirements, the proposed habitat enhancement and mitigation measures will create additional shallow intertidal habitat, functional wetland and riparian plantings, and features to support Tribal fishing access.

Subject to a pending NRDA settlement between the Responsible Party (Jorgensen Forge and Earle M. Jorgensen Company) and the Elliot Bay Natural Resource Trustees, work at Jorgensen Forge and EAA-4 will also include habitat enhancement and mitigation measures to offset natural resource damages (Anchor QEA 2011a, p. 18). Details regarding these tentative plans for habitat mitigation are unavailable and subject to change. The EPA and Jorgensen Forge will provide the Service with additional information as related decisions are made and design details become available.

Much or all of this work will be completed during low tides at elevations above +2 MLLW. We expect that related construction activities will not preclude use of the intertidal zone or otherwise disrupt normal bull trout behaviors (feeding, moving, and sheltering). With full and successful implementation of the agreed-upon conservation measures, we expect that the proposed habitat enhancement and mitigation measures will have an insignificant effect, and/or beneficial effect, on bull trout, their habitat, and prey resources.

Entrainment, Stranding, or Handling

With full and successful implementation of the agreed-upon conservation measures, we expect that the EPA and Applicants can and will completely avoid entrainment, stranding, or direct handling of bull trout individuals.

All in-water work located at elevations below +2 MLLW will be completed during the approved in-water work windows, when bull trout are least likely to be present (Jorgensen Forge Facility and EAA-4, August 1 to February 15; Boeing Plant 2 and DSOA, August 1 to February 15). Based on location, timing, and the inherent nature of the work, we conclude that dredge removal of contaminated sediments with an environmental clamshell bucket, conventional clamshell bucket, or diver-operated hydraulic dredge, is extremely unlikely to result in entrainment, injury, or mortality of bull trout individuals.

Work located at elevations above +2 MLLW will be completed during low tides. The best opportunities to complete this work include the low and extreme-low tides of early- and mid-summer, when bull trout presence in the lower Duwamish cannot be ruled-out. However, with full and successful implementation of the agreed-upon conservation measures, including placement of thin (3 to 6 inch) sand covers over completed dredge cuts, we conclude that excavation of contaminated media and other work on the intertidal zone (i.e., removal of creosote-treated wood piles and other debris; controlled demolition and removal of overwater structures and bulkheads) is extremely unlikely to result in entrainment, stranding, or direct handling of bull trout individuals. The Service expects that work completed during low tides at elevations above +2 MLLW will not result in injury or mortality of bull trout individuals, and will not disrupt normal bull trout behaviors (feeding, moving, and sheltering).

With full and successful implementation of the agreed-upon conservation measures, we conclude that entrainment, stranding, or direct handling of bull trout individuals is extremely unlikely and therefore discountable.

Effects to Bull Trout Prey Resources

Dredge removal of contaminated sediments, and subsequent placement of clean back-fill, will result in measurable short term effects to substrate condition and benthic prey abundance and productivity within the 16.5 acre RABs. With complete removal and replacement of the benthos to a depth of several feet throughout the RABs, it is not possible to avoid these measurable, short term effects to habitat and bull trout prey resources.

Most of the benthic habitat located within the RABs is subject to disturbance resulting from routine maintenance dredging and regular use of the waterway's navigational channel. It is widely accepted that benthic habitats which are subject to these forms of regular disturbance typically support a community of more tolerant benthic organisms.

Several recent studies have examined benthic community response to large and small dredging projects (Guerra-Garcia et al. 2003; Kotta et al. 2009; Merkel and Associates 2009). These studies consistently report measurable short term effects, but also rapid recolonization and recovery of the benthic community within one or two years of disturbance.

We expect that dredging and placement of back-fill will measurably reduce benthic prey abundance and productivity within the RABs for a duration of one to two years. We expect that benthic organisms will rapidly recolonize and recruit to the clean back-fill, and that there will be little or no noticeable change to community composition and long term productivity within the RABs.

It is unlikely that the action will cause a fundamental shift in aquatic community composition and structure, or a permanent change to primary production or nutrient and organic cycling and dynamics. By substantially reducing sources of chronic contaminant exposure, it is possible that the action may allow for recolonization by comparatively less tolerant benthic organisms.

We expect measurable temporary effects to bull trout prey resources within the RABs, including a temporary loss of benthic prey production and availability. However, it is safe to assume that the adult and subadult bull trout that forage within the action area prey mostly upon other fish, and do not rely significantly upon the benthic prey resources that are found within the RABs.

Given the limited size and duration of foreseeable temporary effects to bull trout prey resources, we conclude that the action will not significantly reduce bull trout foraging opportunities or success within the action area, and therefore will not significantly disrupt normal bull trout behaviors. In the long term, we expect that the action will provide measurable benefits in the form of a healthier prey base with reduced contaminant burdens. With full and successful implementation of the agreed-upon conservation measures, we expect that the action will have an insignificant effect, and/or long term beneficial effect, on bull trout prey resources.

Adverse Effects of the Action (Bull Trout)

The proposed action will have measurable adverse effects to bull trout and to designated bull trout critical habitat. Construction activities will directly affect instream habitat that supports bull trout and bull trout may be present at the time of construction. However, suitable bull trout rearing and spawning habitats are not present in the action area, and therefore the proposed action will have no effect on bull trout rearing or spawning habitat, or these essential behaviors.

Construction activities completed at elevations below +2 MLLW, specifically dredge removal of contaminated sediments and placement of clean back-fill, will temporarily degrade surface water quality. We expect that these construction activities will expose adult and subadult bull trout to elevated levels of turbidity, re-suspended river sediments contaminated with PCBs, VOCs (including PAHs and phthalates), and metals, and to elevated water column concentrations of these same hazardous contaminants resulting from sediment re-suspension, release of contaminated interstitial pore water, and/or discharge of treated return water. These impacts to water quality and resulting exposures will be temporary and episodic, but will persist on an intermittent basis over multiple construction seasons (2012-2015). Temporary exposures causing a significant disruption to normal bull trout behaviors (feeding, moving, or sheltering), or potentially resulting in sublethal effects with significance for growth and long term survival, will be confined to the area of the RABs between RM 2.8 and 3.6 of the lower Duwamish River; approximately 1.5 acres (Jorgensen Forge and EAA-4) and 15 acres (Boeing Plant 2 and DSOA) of the lower Duwamish.

Construction activities completed at elevations below +2 MLLW will also temporarily degrade or impair function of the PCEs of designated bull trout critical habitat. Impacts to water quality will impair function of the migratory corridor on an intermittent basis, but over multiple construction seasons (2012-2015). Dredge removal of contaminated sediments and placement of clean back-fill may also measurably degrade bull trout prey resources within the action area. For a fuller discussion of the action's potential effects to the PCEs of designated bull trout critical habitat, please see a sub-section that follows (*Effects to Bull Trout Critical Habitat*).

The proposed action will permanently remove, in total, approximately 270,000 cy of contaminated media (sediment and soils) from more than 16.5 acres of the lower Duwamish and adjacent uplands. These actions include related source control measures to prevent re-contamination, and habitat enhancement and mitigation measures to partially offset the environmental and natural resource damages. The Service expects that the proposed action will improve sediment and water quality conditions in these portions of the lower Duwamish, will reduce long term contaminant exposure risks with ecological benefits, and contribute to the comprehensive Lower Duwamish Waterway Superfund Site cleanup and remediation effort.

The sub-sections that follow discuss the adverse effects to bull trout individuals, their habitat, and prey resources which we expect will result from temporary exposures to elevated turbidity and sedimentation, and from temporary exposures to hazardous contaminants. These sub-sections also discuss chronic contaminant exposures and effects.

Exposure to Elevated Turbidity and Sedimentation During Construction

We expect that construction activities completed at elevations below +2 MLLW, specifically dredge removal of contaminated sediments and placement of clean back-fill, will produce measurable, temporary increases in turbidity and sedimentation. We expect that temporary increases in turbidity and sedimentation will significantly disrupt normal bull trout behaviors (i.e., ability to successfully feed, move, and/or shelter). Increases in turbidity resulting from dredging and placement of back-fill may cause bull trout to temporarily avoid the area, may impede or discourage free movement through the area, prevent individuals from exploiting preferred habitats, and/or expose individuals to less favorable conditions.

Estimate of the Extent of Effect

Anadromous adult and subadult bull trout are known to occur in the action area, and presumably originate from the local populations of the Puyallup River, Snohomish-Skykomish River, and Skagit River core areas. Bull trout may occupy these portions of the lower Duwamish River at any time of year, but information is not available to reliably estimate the number of bull trout that forage, migrate, and overwinter in the action area.

Although few studies have specifically examined the issue as it relates to bull trout, increases in suspended sediment affect salmonids in several recognizable ways. The variety of effects of suspended sediment may be characterized as lethal, sublethal or behavioral (Bash et al. 2001, p. 10; Newcombe and MacDonald 1991, pp. 72-73; Waters 1995, pp. 81-82). Lethal effects include gill trauma (physical damage to the respiratory structures)(Curry and MacNeill 2004, p. 140) and smothering and other effects that can reduce egg-to-fry survival (Bash et al. 2001, pp. 17-18; Cederholm and Reid 1987, p. 384; Chapman 1988, pp. 12-16).

Sublethal effects include physiological stress reducing the ability of fish to perform vital functions (Cederholm and Reid 1987, pp. 388, 390), severely reduced respiratory function and performance (Waters 1995, p 84), increased metabolic oxygen demand (Servizi and Martens 1991, p. 497), susceptibility to disease and other stressors (Bash et al. 2001, p. 6), and reduced feeding efficiency (Newcombe and MacDonald 1991, p. 73). Sublethal effects can act separately or cumulatively to reduce growth rates and increase fish mortality over time. Behavioral effects include avoidance, loss of territoriality, and related secondary effects to feeding rates and efficiency (Bash et al. 2001, p. 7). Fish may be forced to abandon preferred habitats and refugia, and may enter less favorable conditions and/or be exposed to additional hazards (including predators) when seeking to avoid elevated concentrations of suspended sediment.

In order to assess the suspended sediment concentrations at which adverse effects will occur, and to determine the upstream and downstream extent to which these effects may extend, we used the analytical framework attached as Appendix D (USFWS 2010). This framework uses the findings of Newcombe and Jensen (1996) to evaluate the "severity-of-effect" (SEV) based on suspended sediment concentration, exposure, and duration. Factors influencing suspended sediment concentration, exposure, and duration include waterbody size, volume of flow, the nature of the construction activity, construction methods, erosion controls, and substrate and sediment particle size. Factors influencing the SEV include duration and frequency of exposure, concentration, and life stage. Availability and access to refugia are other important considerations.

The framework in Appendix D requires an estimate of suspended sediment concentration (mg/L) and exposure duration. Data collected at the long term water quality monitoring station in closest proximity (WDOE 2012) was used to determine the ratio of turbidity, measured in nephelometric turbidity units (NTUs), to suspended solids (1 NTU : 2.52 mg/L). To determine exposure duration, the Service assumed that construction activities completed at elevations below +2 MLLW would occur 12 hours a day, for as many as 450 working days. It is important to note, the Service expects that any measurable increases in turbidity will be temporary and episodic, but will persist on an intermittent basis over multiple construction seasons (2012-2015).

Using this approach, we expect that adverse effects to adult and subadult bull trout, resulting from temporary increases in turbidity and associated sublethal exposures, are likely to occur under the following circumstances:

1. When background NTU levels are exceeded by 160 NTUs at any point in time.

2. When background NTU levels are exceeded by 59 NTUs for more than 1 hour, continuously, over a 12-hour workday.

3. When background NTU levels are exceeded by 18 NTUs for more than 7 hours, cumulatively, over a 12-hour workday.

4. When background NTU levels are exceeded by 9.5 NTUs for the duration of an entire workday, or longer.

Based on the nature of the proposed work, and with implementation of the proposed conservation measures, we expect that suspended sediment concentrations resulting in adverse effects to bull trout are reasonably certain to occur as far as 800 ft from the ongoing, sediment-generating activity. [Note: the EPA and Applicants have tentatively identified an allowable mixing-zone/compliance boundary positioned approximately 150 ft upstream and downstream of sediment-generating activities.]

The Service expects that low numbers of foraging and migrating adult and subadult bull trout will be in the action area at the time of construction and may be exposed to elevated turbidity and sedimentation. Temporary exposures resulting in adverse effects to bull trout may occur at any time during the approximately 450 day period (Jorgensen Forge Facility and EAA-4: August 1, 2013 to February 15, 2014; Boeing Plant 2 Facility and DSOA: August 1, 2012 to February 15, 2015). Exposures may occur anywhere within the approximately 16.5 acre RABs, but will be confined to only a small portion of the RABs at any one time.

We expect that some bull trout will avoid the ongoing, sediment-generating activity. Resulting turbidities may also impede or discourage free movement through the area, may prevent individuals from exploiting preferred habitats, and/or expose individuals to less favorable conditions. Use of the area may be precluded until suspended sediment concentrations diminish. Exposures to elevated turbidity and sedimentation will result in a significant temporary disruption of normal bull trout behaviors (i.e., ability to successfully feed, move, and/or shelter). Suitable bull trout spawning and rearing habitats do not occur within the action area, and therefore construction activities completed at elevations below +2 MLLW will have no effect on bull trout rearing or spawning habitat, or these essential behaviors.

Acute Exposure to Hazardous Contaminants

Construction activities completed at elevations below +2 MLLW, specifically dredge removal of contaminated sediments and placement of clean back-fill, will temporarily degrade surface water quality. We expect that these construction activities will expose adult and subadult bull trout to re-suspended river sediments contaminated with PCBs, VOCs, and metals, and to elevated water column concentrations of these same hazardous contaminants resulting from sediment re-suspension, release of contaminated interstitial pore water, and/or discharge of treated return water. These impacts to water quality and resulting exposures will be temporary and episodic, but will persist on an intermittent basis over multiple construction seasons (2012-2015). Temporary exposures causing a significant disruption to normal bull trout behaviors (feeding, moving, or sheltering), or potentially resulting in sublethal effects with significance for growth and long term survival, will be confined to the area of the RABs between RMs 2.8 and 3.6 of the lower Duwamish River.

Whether exposed bull trout may suffer lethal or sublethal effects (e.g., reduced growth, reproductive fitness, or long term survival), is difficult to determine with available information, and given potential contingencies and uncertainties. However, the best available science leads us to conclude, with a high degree of certainty, that acute contaminant exposures resulting from the proposed action will cause measurable adverse effects.

The Service relies on toxicity data for other salmonids when information specific to bull trout is not available. Due to taxonomic similarity, species in the Salmonidae family are considered better surrogates for bull trout than non-salmonids. However, Hansen et al. (Hansen et al. 2002) demonstrate that even among the members of Salmonidae sensitivities to chemical contaminants and mixtures of contaminants may differ. The Service has relied on toxicity data for species in the following preferential order: species (bull trout), genus (*Salvelinus*), family (Salmonidae).

Rainbow trout (*Oncorhynchus mykiss*) are the primary freshwater fish species used by the EPA when developing toxicity data for regulatory purposes. Therefore, the majority of data available are from studies using rainbow trout as test subjects.

The most commonly reported end points in the toxicity literature are concentrations at which 50 percent of the test subjects/population died (LC50). Concentrations that result in the death of a smaller percentage of the test population (e.g., LC10) are likely to be somewhat lower. Bull trout and other salmonids would be adversely affected if exposed to contaminant concentrations with the potential to result in acute toxicity and death, if exposed to contaminant concentrations likely to cause measurable sublethal effects (e.g., reduced growth or reproductive fitness), or if exposed to contaminant concentrations sufficient to significantly disrupt normal behaviors (feeding, moving, and sheltering).

Throughout the RABs, surface and subsurface sediments exhibit complex, variable, and discontinuous patterns of contamination. Some areas exhibit relatively high concentrations of one or more contaminants of concern, including PCBs, PAHs, dioxins/furans, VOCs, and metals, while other areas (even in close proximity) appear to contain only low concentrations. Even though some of the highest contaminant concentrations have been detected in subsurface samples, most notably for total PCBs and arsenic, the depth interval of maximum concentration is located within 4 ft of the surface sediment layer for most contaminants of concern.

Seep and pore water collected from areas adjacent to known, upland sources of contamination has been found to contain metal concentrations exceeding State of Washington acute marine water quality criteria for arsenic, copper, and zinc. For a fuller discussion of the baseline environmental conditions, including patterns of existing sediment and water contamination within the RABs and project area, please see a previous section (*Environmental Baseline in the Action Area*).

PCBs, PAHs, and metals are present in sediments at concentrations which, if re-suspended and allowed to desorb to the surrounding water column, may cause adverse effects to acutely exposed fish. In order to assess the potential for adverse effects stemming from acute exposures, it is necessary to know something of the exposure concentration, duration, and physical extent. Whether acute exposures cause lethal or sublethal effects will be strongly influenced by the exposure concentration and duration. Information is limited and there are important sources of uncertainty. These sources of uncertainty include the actual quantity of contaminated sediment that will or may be re-suspended, the composition and contaminant concentrations in that re-suspended sediment, the quantity and chemical composition of released interstitial pore water, and the rate or degree of contaminant desorption to the surrounding water column. Additional sources of uncertainty include the effect of intermittent, episodic, or transient exposures (Burton et al. 2000; Marsalek et al. 1999), variations in tolerance among exposed individuals, populations, and/or species (Ellis 2000, p. 89; Hodson 1988; Lloyd 1987, p. 502), and, the potential for additive or synergistic effects among contaminants with similar or the same modes of toxic action (Burton et al. 2000; Ellis 2000, p. 88; Lloyd 1987, p. 494). Burton et al. (Burton et al. 2000) warn that traditional toxicity tests may not lead to reliable conclusions if not tailored to reflect "real-world" patterns of exposure. Lloyd (1987, pp. 492, 501) suggests that contaminants may be more toxic to salmonids when dissolved oxygen is reduced, and advises that water quality standards should apply to whole groups of contaminants with common modes of action, rather than individual contaminants.

A number of site-specific conditions will influence the spatial extent of potential exposures. Acute exposures are usually most intense in the initial mixing zone where sediment re-suspension creates a three-dimensional plume that dissipates vertically, horizontally, and longitudinally (Bridges et al. 2008, pp. 6-8, 15, 18). The size and shape of the temporary plume, and therefore the spatial extent of potential contaminant exposures, will be influenced by the quantity and chemical composition of re-suspended sediment, the rate or degree of contaminant desorption to the surrounding water column, particle size and resettling rate, discharge volume, current, tidal flux, degree of turbulence, height of release to the water column, sheer stress at the channel bottom, water temperature and salinity, and operational considerations (Bridges et al. 2008, pp. 5, 7-9, 13, 20, 42).

Without the information needed to definitively model the spatial component of potential exposures, we relied on best professional judgment and a number of simplifying assumptions. We employed the same methods used previously by the Service when addressing a large construction project located within these same portions of the Duwamish River (Opinion – South Park Bridge Replacement, August 17, 2009; FWS Ref. No. 13410-2008-F-0383). Instantaneous partitioning and equilibrium of the sediment and water column contaminant concentrations is our most important "worst-case" assumption (Bridges et al. 2008, pp. 22, 37; Herrera Environmental Consultants, in litt. 2007, pp. 8, 10). Under most conditions where sediment re-suspension and contaminant desorption to the water column determine exposure, equilibrium partitioning will not be achieved (Bridges et al. 2008, p. 18; Herrera Environmental Consultants, in litt. 2007, p. 10). Therefore, by assuming that instantaneous partitioning and equilibrium will occur, we may over-estimate (but we are not likely to under-estimate) the size or intensity of the resulting contaminant plume.

Empirical evidence suggests that contaminant plumes resulting from dredging frequently transition from "near field zone" processes (including potential acute exposures), to "far-field zone" processes within 100 meters of the operation (Bridges et al. 2008, p. 7). However, some dredging operations have been shown to cause large and very intense turbidity plumes (Phipps et al. 1992 in USACE 2006, pp. 12-14). Therefore, we expect that temporary exposures with a potential to cause adverse effects in bull trout may likely extend to a greater distance from the on-going activity.

It is possible, though unlikely, that resulting contaminant plumes may at times span the entire channel. More typically, however, we expect that contaminant plumes will occupy only a portion of the channel cross-section, and only a small portion of the RABs and action area, at any one time. Acute contaminant exposures with a potential to cause measurable adverse effects to bull trout will be confined to the same area where suspended sediment concentrations are elevated over ambient, background conditions; i.e., to a distance of approximately 800 ft upstream and downstream of the ongoing, sediment-generating activity, depending upon the direction of tidal flux. Temporary exposures resulting in adverse effects to bull trout may occur at any time during the approximately 450 day period (Jorgensen Forge Facility and EAA-4:

August 1, 2013 to February 15, 2014; Boeing Plant 2 Facility and DSOA: August 1, 2012 to February 15, 2015). Exposures may occur anywhere within the approximately 16.5 acre RABs, but will be confined to only a small portion of the RABs at any given time.

Acute contaminant exposures resulting from sediment re-suspension, release of contaminated water, and/or discharge of treated return water will be limited in duration and extent, but some of the anticipated effects (e.g., reduced growth or reproductive fitness) may last for the lives of the exposed individuals. There is at least some risk of lethal exposures for a limited number of bull trout. Contaminants released to the water column may also significantly disrupt normal bull trout behaviors (i.e., ability to successfully feed, move, and/or shelter), including predator avoidance behaviors.

Polychlorinated Biphenyls (PCBs)

The PCBs are a class of synthetic organic chemical compounds, consisting of 1 to 10 chlorine atoms attached to a biphenyl group (two bonded benzene rings). These compounds originate from various industrial sources and processes, including dielectric fluids in transformers and capacitors, coolants, lubricants, electrical wiring and components, pesticides, cutting oils, flame retardants, hydraulic fluids, sealants, adhesives, paints and finishes, and dust control agents (EPA 2012b). As an environmental contaminant, these compounds are of concern because of their documented carcinogenic, mutagenic, and teratogenic properties, and because they have the potential to bioaccumulate. The toxicological literature reports reduced fertilization success and egg survival, reproductive failure, reduced growth, liver malfunction, and altered blood and enzyme function as effects to benthic invertebrates and/or fish resulting from exposure to PCBs (EPA 2012b).

PCBs were detected in 94 percent of the samples from the baseline dataset. The mean surface sediment total PCB concentration exceeds the marine CSL. The maximum surface sediment total PCB concentration exceeds the marine CSL by more than two orders of magnitude. Predicted equilibrium water column concentrations for individual Aroclor PCBs, i.e., recognizable mixtures of PCB congeners, are sufficiently high to present a risk of adverse acute exposures and effects (see below). As a group of contaminants with a common mode of toxic action, PCBs also present a risk of toxic interaction and additive or synergistic effects in acutely exposed fish.

Polycyclic Aromatic Hydrocarbons (PAHs)

The PAHs are a class of organic chemical compounds, consisting of fused aromatic rings, commonly found in oil, coal, and tar and frequently occurring in nature as a byproduct of fuel burning and/or incomplete combustion. As an environmental contaminant, these compounds are of concern because of their documented carcinogenic, mutagenic, and teratogenic properties, and because they show an apparent tendency for bioaccumulation (EPA 2008). Many of the PAHs are potent carcinogens, and a host of other (i.e., non-cancer-causing) potential biological effects are poorly understood. In aquatic systems, the high-molecular-weight PAHs tend to exhibit greater toxicity than do the low-molecular-weight PAHs. The toxicological literature reports inhibited reproduction, delayed emergence, liver disease or malfunction, morphological abnormalities, immune system impairment, and mortality as effects to benthic invertebrates and/or fish resulting from exposure to PAHs (EPA 2008).

High- and low-molecular-weight PAHs (H-PAHs and L-PAHs) were detected in 98 percent and 94 percent of the samples from the baseline dataset, respectively. Mean surface sediment total H-PAH and L-PAH concentrations are below both the marine SQSs and CSLs. However, maximum surface sediment total H-PAH and L-PAH concentrations are three to five times greater than the marine CSLs. Predicted equilibrium water column concentrations for several PAHs are sufficiently high to present a risk of adverse acute exposures and effects (see below). As a group of contaminants with a common mode of toxic action, PAHs also present a risk of toxic interaction and additive or synergistic effects in acutely exposed fish.

Metals

There are three known physiological pathways by which salmonids may uptake metals: 1) uptake of ionic metals at the gill surfaces (Niyogi et al. 2004), 2) dietary uptake, and 3) olfaction (sense of smell) involving receptor neurons (Baldwin et al. 2003). Of these three pathways, the mechanism of dietary uptake is least understood. For dissolved metals, the most direct pathway is through the gill surfaces.

Measurements of total recoverable metal concentration include a fraction that is bound to suspended solids and/or complexed with organic matter or other ligands; this fraction is not available to bind to gill receptor sites. As such, most metal toxicity studies have examined the dissolved metal fraction which is more bioavailable and therefore of greater significance for acute exposure and toxicity.

The relative toxicity of a metal can be altered by hardness, water temperature, pH, organic content, phosphate concentration, suspended solid concentration, the presence of other metals or contaminants (i.e., synergistic effects), and other factors. Eisler (1998) and Playle (2004) found that dissolved metal mixtures exhibit greater than additive toxicity. Water hardness affects the bio-available fraction of metals; as hardness increases, metals become less bio-available for uptake at the gill surfaces and therefore less toxic (Hansen et al. 2002; Niyogi et al. 2004).

Metals, including copper and zinc, were detected in all samples from the baseline dataset. Mean surface sediment metal concentrations are below both the marine SQSs and CSLs. However, maximum surface sediment metal concentrations exceed the marine SQSs and CSLs by at least one order of magnitude. In addition, seep and pore water collected from areas adjacent to known, upland sources of contamination has been found to contain metal concentrations exceeding State of Washington acute marine water quality criteria for copper and zinc. Predicted equilibrium water column concentrations for copper and zinc are sufficiently high to present a risk of adverse acute exposures and effects (see below).

Copper

Even at low concentrations, copper is acutely toxic to fish. Effects of exposure to copper include 1) weakened immune function and impaired disease resistance, 2) impaired respiration, 3) disruptions to osmoregulation, 4) impaired function of olfactory organs and brain, 5) altered blood chemistry, 6) altered enzyme activity and function, and 7) pathology of the kidneys, liver, and gills (Eisler 1998).

The acute lethality of copper has been evaluated for bull trout. Hansen et al. (2002) examined acute toxicity and determined that rainbow trout fry and bull trout fry have similar sensitivities. The authors describe a 96-hour and 120-hour LC50 for bull trout under test conditions (100 mg/L hardness and 8 °C), approximately 66.6 and 50.0 μg/L, respectively.

Baldwin et al. (2003) found that short pulses of dissolved copper, at concentrations as low as 2 μg/L, reduced olfactory sensory responsiveness by approximately 10 percent within 10 minutes, and by 25 percent within 30 minutes. At 10 μg/L responsiveness was reduced by 67 percent within 30 minutes. Baldwin et al. (2003) identified a copper concentration neurotoxic threshold of an increase of 2.3 to 3.0 μg/L, when background levels are 3.0 μg/L or less. When exceeded, this threshold is associated with olfactory inhibition. The authors also reference three other studies examining long-duration copper exposures (i.e., exceeding 4 hours); these studies found that long-duration exposures resulted in cell (olfactory receptor neuron) death in rainbow trout and Atlantic and Chinook salmon. Baldwin et al. (2003) found that water hardness did not influence the toxicity of copper to coho salmon sensory neurons.

More recently, Sandahl et al. (2007) documented sensory physiological impairment, and related disruption to predator avoidance behaviors, in juvenile coho at concentrations as low as 2 μg/L dissolved copper.

The effects of short-term copper exposure may persist for hours and possibly longer. Although salmonids may actively avoid surface waters containing an excess of dissolved copper, exposed individuals may experience olfactory function inhibition. Avoidance of a chemical plume may cause fish to leave refugia or preferred habitats in favor of less suitable or less productive habitats. This, in turn, can make fish more vulnerable to predation and can impair foraging success, feeding efficiency, and thereby growth.

Folmar (1976) observed avoidance responses in rainbow trout fry when exposed to a Lowest Observed Effect Concentration of 0.1 μg/L dissolved copper (hardness of 90 mg/L). The EPA (1980a) also documented fry avoidance of dissolved copper concentrations as low as 0.1 μg/L during a 1 hour exposure, as well as a LC10 for smolts exposed to 7.0 μg/L for 200 hours, and a LC10 for juveniles exposed to 9.0 μg/L for 200 hours.

Zinc

Zinc occurs naturally in the environment and is an essential trace element for most organisms. However, in sufficient concentrations and when bioavailable for uptake by aquatic organisms, excess zinc is toxic. Toxicity in the aquatic environment and for exposed aquatic organisms is influenced by water hardness, pH, organic matter content, levels of dissolved oxygen, phosphate, and suspended solids, the presence of mixtures (i.e., synergistic effects), trophic level, and exposure frequency and duration (Eisler 1993). Bioavailability of zinc increases under conditions of high dissolved oxygen, low salinity, low pH, and/or high levels of inorganic oxides and humic substances. Most of the zinc introduced into aquatic environments is eventually partitioned into sediments (Eisler 1993).

Effects of zinc exposure include 1) weakened immune function and impaired disease resistance (Ghanmi et al. 1989), 2) impaired respiration, including potentially lethal destruction of gill epithelium (Eisler 1993), 3) altered blood and serum chemistry, and enzyme activity and function (Hilmy et al. 1987a; Hilmy et al. 1987b), 4) interference with gall bladder and gill metabolism (Eisler 1993), 5) hyperglycemia, and 6) jaw and branchial abnormalities (Eisler 1993).

Hansen et al. (2002) determined 120-day lethal concentrations of zinc for test subjects that included bull trout and rainbow trout fry. Multiple pairs of tests were performed with a nominal pH of 7.5, hardness of 30 mg/L, and at a temperature of 8 °C. Bull trout LC50 values measured under these conditions ranged from 35.6 to 80.0 µg/L, with an average of 56.1 µg/L. Hansen et al. (2002) found that rainbow trout fry are more sensitive to zinc (i.e., exhibit a lower LC50) than are bull trout fry. The authors also report that older, more active juvenile bull trout are more sensitive than younger, more docile juvenile bull trout based on observed changes in behavior at the juvenile life stage. The authors argue that the timing of zinc and cadmium exposure and the activity level of the exposed fish are germane to predicting toxicity in the field.

The mode of action for zinc toxicity relates to net loss of calcium. Studies suggest that zinc exposure inhibits calcium uptake, although it appears this effect is reversible once fish return to clean water. The apparent difference in sensitivity between rainbow trout and bull trout may be due to the lesser susceptibility of bull trout to calcium loss. Hansen et al. (2002) state that differences in sensitivity between these two salmonids may reflect different physiological strategies for regulating calcium uptake. These strategies may include gills that differ structurally, differences in the mechanisms for calcium uptake, and/or variation in resistance to or tolerance for calcium loss.

There are no known studies or data describing adult bull trout response to lethal or near-lethal concentrations of zinc. Active feeding and increased metabolic activity are apparently related to sensitivity. It is unknown whether sensitivity to zinc varies between adult, subadult, and juvenile bull trout. Activity level may be a better predictor of sensitivity than age.

In addition to the physiological effects of zinc exposure, studies have also documented a variety of behavioral responses. Among these, Eisler (1993) includes altered avoidance behavior, decreased swimming ability, and hyperactivity. The author also suggests zinc exposure has implications for growth, reproduction, and survival.

Sublethal endpoints have been evaluated with test subjects that include both juvenile and adult rainbow trout (Eisler 1993; USEPA 1980b; USEPA 1987). Some of these test results clearly indicate that juvenile rainbow trout are more sensitive than adult rainbow trout. Using juvenile rainbow trout as test subjects, studies have found that sublethal effects occur at concentrations approximately 75 percent lower (5.6 μg/L) than the concentrations that result in lethal effects (24 μg/L) (Eisler 1993; Hansen et al. 2002). Sprague (1968) found that at concentrations as low as 5.6 μg/L juvenile rainbow trout exhibit avoidance behavior. Avoidance of a chemical plume may cause fish to leave refugia or preferred habitats in favor of less suitable or less productive habitats. This can make fish more vulnerable to predation and can impair foraging success, feeding efficiency, and thereby growth.

Estimate of Exposure Concentration, Duration, and Extent

Without the information needed to definitively model the spatial component of potential exposures, we relied on best professional judgment and a number of simplifying assumptions. We employed the same methods used previously by the Service when addressing a large construction project located within these same portions of the Duwamish River (Opinion – South Park Bridge Replacement, August 17, 2009; FWS Ref. No. 13410-2008-F-0383). Methods have been described in greater detail elsewhere (Herrera Environmental Consultants, in litt. 2007).

In order to assess the potential for adverse effects stemming from acute exposures, it is necessary to know something of the exposure concentration, duration, and physical extent. We applied accepted methods, and used conservative assumptions (e.g., instantaneous equilibrium partitioning), to predict the equilibrium PCB, PAH, and dissolved metal water column concentrations that might result from re-suspension of contaminated sediments, desorption to the surrounding water column, release of contaminated water, and/or discharge of treated return water.

These temporary, elevated water column concentrations were then compared to Toxicity Reference Values (TRVs) obtained from the toxicological literature. Ecological TRVs are "...species-specific and chemical-specific estimates of an exposure level that is not likely to cause unacceptable adverse effects on growth, reproduction, or survival," and are generally based on dose-response studies conducted under controlled laboratory conditions (EPA 2012a). TRVs must be selected with care since whole classes of organisms (e.g., benthic invertebrates, fishes, and mammals), species, populations, and individuals can exhibit varying sensitivities or tolerances for environmental contaminants. If TRVs are selected such that they represent the tolerances of a relativity more sensitive receptor among the full range of potential receptors, then comparisons with these TRVs should provide a reliable, conservative means for assessing the risk of adverse effects to the group of potential receptors as a whole (EPA 2012a). However, the derivation of TRVs is an emerging science and there is not, as yet, a universally accepted set of TRVs. The Service has not endorsed, and does not intend to endorse here, a particular set of TRVs for the assessment of potential adverse effects to Act-listed species or critical habitat.

Hazard Quotients (HQs) provide a numerical comparison of exposure concentrations and TRVs. If a HQ is greater than 1.0, then the exposure concentration exceeds the TRV selected for comparison, and exposed receptors may be at some risk of adverse effects. Higher HQs indicate an increased probability of effect to sensitive species, and "...as the HQ for [a group of receptors] becomes larger, it is expected that more and more [receptors] in the group would be at risk" (EPA 2012a).

Table 5 provides a summary of our findings. It presents predicted, maximum, equilibrium PCB, PAH, and dissolved metal water column concentrations, and allows for comparisons with contaminant-specific TRVs. Table 5 also presents associated HQs for Aroclor PCBs (i.e., recognizable mixtures of PCB congeners), Total PCBs, several of the PAHs, and metals.

These findings suggest that water column concentrations for copper, three PAHs (anthracene, fluoranthene, and fluorene), and Aroclor-1254 will substantially exceed TRVs and are reasonably certain to result in measurable, adverse acute exposures and effects. The same can be said, with less certainty (and perhaps with less severity of effect), for elevated water column concentrations of zinc, phenanthrene, pyrene, and Aroclor-1260.

Table 5. Predicted water column concentrations for select contaminants of concern, with comparison to TRVs.

Contaminant of Concern	Max. Concentration[a] in Sediments (μg/kg)	**Max. Water Column Concentration (μg/L)**	TRV (μg/L)	**Hazard Quotient**
Copper	12,000*	165.9**	2.3	72.1
Zinc	9,700*	67.1**	23.9	2.8
Anthracene	4,400	10.5	1.3	8.1
Fluoranthene	10,000	11.5	0.9	12.8
Fluorene	1,500	10.7	0.8	13.4
Phenanthrene	4,900	13.2	7.7	1.7
Pyrene	3,900	3.3	0.8	4.1
Aroclor-1254	110,000	61.1	10	6.1
Aroclor-1260	51,000	28.3	10	2.8
Total PCBs	110,000	0.4	10	0.04

Source: [a] (AMEC and FSI 2011)

* For metals (copper and zinc), concentration in sediments is measured as mg/kg dry weight (or parts per million).

** For metals, the predicted maximum water column concentration has been adjusted downward to represent the bioavailable, dissolved fractions. Total-to-dissolved translator values (Cu - 0.693; Zn - 0.871) were obtained from Ecology's Phase 2 study of toxic chemicals in Puget Sound (EnviroVision et al. 2008).

The PCBs, the PAHs, and dissolved metals, as groupings or classes of related contaminants, present a risk of additive or synergistic effects. The various PAHs cause effects in exposed receptors by similar or the same modes of toxic action, as do the various PCBs. As a means to address this potential for toxic interaction, Table 6 presents Hazard Indices which sum individual HQs for the PCBs, PAHs, and metals. These findings lend still more support for the conclusion that temporary, elevated water column concentrations are reasonably certain to cause measurable, adverse effects in acutely exposed fish.

Table 6. Hazard indices for metals, PAHs, and PCBs desorbing to the water column.

Contaminant Group	Hazard Index
Metals	74.9
PAHs	40.1
Aroclor PCBs	8.9

It should be noted that these predicted water column concentrations represent conservative estimates. In addition, the TRVs have been developed through laboratory dose-response studies employing long exposure durations (e.g., 24-hour/day, 4- to 7-day test periods), and it is unlikely that individual bull trout would be exposed for these durations. However, when adjusted for more realistic or relevant exposure durations (e.g., 3, 6, or 12 hour exposures), the Hazard Indices would be substantially lower, but still two to six times greater than would be associated with little or no risk of adverse effects (i.e., HQ less than or equal to 1.0).

Taken as whole, these findings (i.e., predicted water column concentrations, HQs, Hazard Indices, and duration-adjusted Hazard Indices) would lead us to conclude that acute contaminant exposures resulting from the proposed action will cause measurable adverse effects with a high degree of certainty.

It is difficult to determine with available information whether exposed bull trout may suffer lethal or sublethal effects as a result of these acute contaminant exposures. However, Hazard Indices adjusted for shorter and more realistic exposure durations are relatively low. Accordingly, we expect that most bull trout that are acutely exposed to temporarily elevated PCB, PAH, and dissolved metal water column concentrations will not suffer lethal effects (i.e., immediate or delayed mortality), but will instead experience less severe sublethal effects. These sublethal effects may include an incremental reduction in growth or long term reproductive fitness.

The Service expects that the contaminant plumes resulting from the proposed action will be temporary and will occupy only a portion of the channel cross-section, and only a small portion of the RABs and action area, at any one time. We expect that acute contaminant exposures with the potential to cause measurable adverse effects to bull trout will be confined to the same area where suspended sediment concentrations are temporarily elevated over ambient, background conditions; i.e., to a distance of approximately 800 ft upstream and downstream of the ongoing, sediment-generating activity, depending upon the direction of tidal flux. Temporary exposures resulting in adverse effects to bull trout may occur at any time during the approximately 450 day period (Jorgensen Forge Facility and EAA-4: August 1, 2013 to February 15, 2014; Boeing Plant 2 Facility and DSOA: August 1, 2012 to February 15, 2015). Exposures may occur anywhere within the approximately 16.5 acre RABs, but will be confined to only a small portion of the RABs at any one time.

The Service expects that low numbers of foraging and migrating adult and subadult bull trout will be in the action area at the time of construction and may be temporarily exposed to sediments and water contaminated with PCB, PAH, and dissolved metal concentrations sufficient to cause measurable adverse effects. Acute exposures will be limited in duration, but some of the anticipated effects (e.g., reduced growth or reproductive fitness) may last for the lives of the exposed individuals.

Both the PCBs and the PAHs are highly toxic, carcinogenic, and fat soluble (lipophilic). The total "body burden," which has significance for the severity of long term effects, may accumulate over the lives of individuals as a result of multiple, repeated exposures (and/or through multiple exposure pathways). Bull trout that are acutely exposed to contaminants as a result of the proposed action will likely have experienced similar exposures elsewhere (and at other times) within the lower Duwamish River and/or marine waters of the Puget Sound. PCB and PAH contamination are pervasive problems throughout the Puget Sound (Hart Crowser et al. 2007), and low- or moderate-level exposures most likely contribute to total body burdens by way of multiple exposure pathways (including the prey base). Available information does not allow us to predict how exposures within the action area might add incrementally to the accumulative effect of multiple exposures over the lives of individual fish. However, over the long term, we expect that acute exposures resulting from the proposed action are likely to result in an incremental reduction in individual growth and/or reproductive fitness.

Chronic Contaminant Exposures and Effects

The proposed action includes excavation and dredge removal of approximately 270,000 cy of contaminated media (sediment and soils) from more than 16.5 acres of the lower Duwamish and adjacent uplands. The RABs are highly contaminated and, even with full implementation of the proposed conservation measures, we expect that construction activities conducted above and below MLLW present some risk of directly mobilizing and transporting contaminated media downstream. We expect that the action will mobilize and transport some amount of PCB, VOC, dioxin/furan, and metal contamination to portions of the lower Duwamish and Elliot Bay located downstream of the RABs and immediate project area. The action will thereby measurably alter patterns of contaminant exposure, for a period both during and after construction, within and outside the RABs.

In the long term, we expect that the action will measurably improve sediment and water quality conditions within the RABs and elsewhere, will contribute to the planned comprehensive cleanup and remediation effort along the lower Duwamish, and thereby provide significant ecological benefits by reducing or eliminating long term contaminant exposure risks. We expect that the action will measurably reduce the extent and severity of chronic contaminant exposures and effects to bull trout, their habitat, and prey resources. No measurable, adverse, long term or permanent effects to bull trout, their habitat, or prey resources are expected.

Bottom sediments in the RABs contain a complex and variable mixture of PCBs, VOCs, dioxins/furans, and metals. A number of these contaminants are present at sediment concentrations that exceed marine and freshwater quality standards and guidelines recommended for the protection of aquatic life. These sediments include a significant fraction composed of fine-grained silts and clays. The smallest of these sediments have very slow settling velocities, and in a system as large as the lower Duwamish may travel long distances before falling out of suspension. The best available science lead us to conclude that some of the re-suspended sediments, and the sediment-bound contamination they carry, may travel the entire length of the lower Duwamish and into Elliot Bay (a distance of approximately 5 miles downstream) before falling out of suspension.

It is difficult to reliably determine what quantities of contamination may fall out of suspension and re-deposit along downstream portions of the lower Duwamish and Elliot Bay. Accordingly, it is also difficult to ascertain how this contamination may incrementally affect bull trout, their habitat, and prey resources within the action area. The RABs are clearly more contaminated than other large portions of the lower Duwamish; 75 percent or more of the lower Duwamish (by area) may be less contaminated than the RABs (Windward Environmental 2010, pp. ES-12, ES-13, ES-30, ES-31). However, there are also numerous sources of these same contaminants along the lowermost six miles of the Duwamish River, including additional EAAs located both upstream (Norfolk CSO) and downstream (Duwamish/Diagonal).

The project area may, in general, be characterized as a depositional reach (AMEC and FSI 2011, pp. 9-13). Contaminated sediment has and is now being buried by relatively less contaminated sediment from upstream. The proposed action will have the effect of temporarily interrupting typical patterns of sediment transport. However, the EPA and Applicants will place clean back-fill approximating pre-project contours, and we expect that the fine-grained channel bed will adjust to altered conditions relatively quickly. We expect that typical patterns of sediment transport will resume in a matter of weeks or months. The proposed action will not affect a permanent change to sediment transport dynamics in the action area.

The Service expects that re-suspension and subsequent downstream resettling or deposition of mobilized sediment will, in the short term, measurably alter patterns of contaminant exposure along some portions of the lower Duwamish. The LDWG has documented effects to the invertebrate community that may be attributable to similar short term releases of contaminated sediment (LDWG 2007, p. 535). The LDWG has been sampling and analyzing tissue chemical concentrations in fish and invertebrates from throughout the lower Duwamish since 1995. During 2004, several months after a series of dredging operations, the LDWG found that tissue total PCB concentrations were "...much higher in some species ... than in older (1995 to 1998) and more recent (2005 and 2006) samples" (LDWG 2007, p. 535). This, they suggest, indicates "...that exposure to total PCBs may have been higher immediately following the dredging events than is typical for the Lower Duwamish Waterway." They also report that increases in tissue chemical concentrations have been documented elsewhere in the country following dredging operations. Some studies have found that short term contaminant releases can be as much as three orders of magnitude greater than baseline, pre-dredging releases (Bridges et al. 2008, p. 19).

Where contaminated sediments are concerned, it is widely accepted that "...exposure processes are dominated by what happens in the top several centimeters of sediment" (Bridges et al. 2008, p. 39). The proposed action will transport to downstream locations a volume of sediment and contamination that might otherwise have presented little risk of direct exposure or effects to bull trout, their habitat, and prey resources. While suspended in the water column, and after resettling or re-depositing along downstream portions of the lower Duwamish and Elliot Bay, this sediment-bound contamination will become more bioavailable (and therefore more biologically relevant) for at least a period of time. It is possible that some of this sediment-bound contamination may re-deposit in areas where the surface sediment layer is less contaminated, or not contaminated at all. This altered pattern of exposure will affect the benthic invertebrate community most directly.

With full and successful implementation of the agreed-upon conservation measures, the Service expects that the amount of contaminated media which is transported downstream and beyond the RABs will be relatively small. Downstream transport and deposition of mobilized sediments will alter patterns of contaminant exposure, at least temporarily, both during and after construction. However, we expect that over a period of months, the widely and thinly dispersed layer of resettled sediment and sediment-bound contamination will become buried by cleaner upstream sources. It is possible that these altered patterns of exposure may cause measurable, temporary increases in benthic invertebrate tissue contaminant concentrations, but we expect it will be difficult or impossible to detect a change in benthic invertebrate community health or productivity outside of the RABs. It is unlikely that the action will cause a fundamental shift in aquatic community composition and structure, or a permanent change to primary production or nutrient and organic cycling and dynamics.

In the long term, the Service expects overwhelmingly positive and beneficial effects to result from the proposed action. While not insignificant, the temporary contaminant exposures and effects resulting from the action will operate on scales that are small in comparison to the baseline level and extent of contamination, and in comparison to the measurable long term benefits we expect throughout the action area. The action will contribute to comprehensive cleanup and remediation efforts along the lower Duwamish River, and thereby measurably reduce the extent and severity of chronic contaminant exposures and effects to bull trout, their habitat, and prey resources. The Service expects no measurable, adverse, long term or permanent effects to bull trout, their habitat, or prey resources.

Summary of Effects (Bull Trout)

An earlier section applied the *Matrix of Diagnostics/Pathways and Indicators* (USFWS 1998) as a tool for describing whether aquatic habitat is properly functioning, functioning at risk, or functioning at unacceptable levels of risk at the scale of the action area (*Environmental Baseline in the Action Area*). Table 7 summarizes the effects of the action using this same matrix. For a fuller description of the anticipated effects of the action see the preceding sub-sections.

Table 7. Effects of the action ("Matrix of Pathways & Indicators").

Pathway	Indicator	Baseline Conditions	Effect of the Action
Water Quality	Temperature	Unacceptable Risk	Maintain
	Sediment	At Risk	**Degrade (Temporary)**
	Chemical Contamination & Nutrients	Unacceptable Risk	**Degrade (Temporary)** **Restore (Long Term)**
Habitat Access	Physical Barriers	At Risk	**Degrade (Temporary)**
Habitat Elements	Substrate	Unacceptable Risk	**Degrade (Temporary)** **Restore (Long Term)**
	Large Woody Debris	Unacceptable Risk	Maintain
	Pool Frequency / Quality	Unacceptable Risk	Maintain
	Large Pools	At Risk	Maintain
	Off-Channel Habitat	Unacceptable Risk	**Maintain, with Limited Restoration**
	Refugia	Unacceptable Risk	Maintain
Channel Conditions & Dynamics	Width/Depth Ratio	Functioning Adequately	Maintain
	Streambank Condition	Unacceptable Risk	**Maintain, with Limited Restoration**
	Floodplain Connectivity	Unacceptable Risk	Maintain
Flow / Hydrology	Peak / Base Flows	At Risk	Maintain
	Drainage Network	Unacceptable Risk	Maintain
Watershed Conditions	Road Density / Location	Unacceptable Risk	Maintain
	Disturbance History	Unacceptable Risk	Maintain
	Riparian Reserve	Unacceptable Risk	Maintain

Effects to Bull Trout Critical Habitat

An earlier section identified the PCEs of bull trout critical habitat and described their baseline condition in the action area (*Status of Critical Habitat in the Action Area*). The following sub-section discusses the effects of the action with reference to the eight PCEs which are present and may be affected. Suitable bull trout spawning habitats are not present in the action area; PCE #6 (*suitable spawning substrates*) is not present and will not be affected.

(1) *Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.*

The action will influence patterns of runoff, infiltration, and subsurface water exchange on a local scale, but will have no discernible effect on the size or frequency of peak, high, low or base flows, or on day-to-day or seasonal fluctuations of the natural hydrograph. The proposed stormwater system improvements will significantly reduce the discharge of conventional industrial stormwater pollutants (solids; total and dissolved metals; etc.), and nearly or completely eliminate all contributions of contaminants of concern to the RABs. The proposed stormwater design will not cause or contribute to measurable increases in surface water temperature, or degrade thermal refugia within the action area.

The action will permanently remove a large quantity of contaminated media from the lower Duwamish River and adjacent uplands, will implement related source control measures to prevent re-contamination, and thereby provide significant, measurable, long term benefits. These benefits will include improved protection of the groundwater resource.

We conclude that foreseeable effects to this PCE will not be measurable, or will be beneficial, and are therefore considered insignificant. Within the action area this PCE will retain its current level of function (severely impaired).

(2) *Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.*

The action will have temporary adverse effects to PCE #2. Construction activities completed at elevations below +2 MLLW, specifically dredge removal of contaminated sediments and placement of clean back-fill, will temporarily degrade surface water quality and function of the migratory corridor. Temporary impacts to water quality may impede or discourage free movement through the area, but will not preclude continued use of the migratory corridor.

The foreseeable temporary adverse effects to the migratory corridor will be limited in both physical extent and duration. Impacts to water quality will be episodic, but will persist on an intermittent basis over multiple construction seasons (2012-2015). Measurable temporary impacts to this PCE will be confined to the area of the RABs between RM 2.8 and 3.6 of the lower Duwamish River. At any one time, we expect that the action will degrade water quality and function of the migratory corridor through only a small portion of the RABs.

The action will measurably diminish the function of the migratory corridor in the short term, but in the long term effects to this PCE will not be measurable, and are therefore considered insignificant. The action will not create or contribute to any permanent physical, biological, or water quality impediments to migration or free movement.

We conclude that the action will have no permanent adverse effects, and will improve long term function of PCE #2.

(3) *An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.*

The action will have temporary adverse effects to PCE #3. With complete removal and replacement of the benthos to a depth of several feet throughout the 16.5 acre RABs, it is not possible to fully avoid measurable, adverse, short term effects to the bull trout prey base.

Temporary adverse effects will be limited in both physical extent and duration. We expect that dredging and placement of back-fill will measurably reduce benthic prey abundance and productivity within the RABs for a duration of one to two years. We expect that benthic organisms will rapidly recolonize and recruit to the clean back-fill.

In the long term, we expect that the action will provide measurable benefits in the form of improved sediment and water quality, reduced contaminant exposure risks, and a healthier prey base with reduced contaminant burdens. With removal of the contamination from the river, the quality and availability of bull trout prey resources may measurably improve over time. We expect reduced bioaccumulation in the native benthos and resident fish populations.

The action will measurably diminish the productivity or availability of bull trout prey in the short term, but in the long term the foreseeable effects to this PCE will not be measurable, or will be beneficial, and are therefore considered insignificant. We conclude that the action will have no permanent adverse effects to PCE #3.

Within the action area this PCE will retain its current level of function (moderately impaired).

(4) *Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks and unembedded substrates, to provide a variety of depths, gradients, velocities, and structure.*

The lower Duwamish River exhibits greatly reduced habitat complexity and diversity. Within the action area, instream habitat complexity and function is substantially diminished compared to historic conditions.

The action will not cause or contribute to a further simplification of instream habitats in either the short or long term. Instead, with the inclusion of habitat enhancement and mitigation measures, including those proposed by the EPA and Applicants to satisfy NRDA requirements, we expect that the action will provide measurable benefits in the form of improved sediment and water quality, reduced long term contaminant exposure risks (including a healthier prey base with reduced contaminant burdens), and modestly improved nearshore intertidal, wetland, and riparian habitat functions.

We conclude that foreseeable effects to this PCE will not be measurable, or will be beneficial, and are therefore considered insignificant. Within the action area this PCE will retain its current level of function (severely impaired).

(5) *Water temperatures ranging from 2 to 15 °C (36 to 59 °F), with adequate thermal refugia available for temperatures that exceed the upper end of this range. Specific temperatures within this range will depend on bull trout life-history stage and form; geography; elevation; diurnal and seasonal variation; shading, such as that provided by riparian habitat; stream flow; and local groundwater influence.*

Sources of cold water are insufficient to maintain water temperatures within the optimal range for bull trout during all times of year. However, the action area does provide pools where bull trout can seek refuge from seasonally high surface water temperatures.

The proposed stormwater design will not cause or contribute to measurable increases in surface water temperature, or degrade thermal refugia within the action area. The action will have no other foreseeable effects to water temperatures.

We conclude that foreseeable effects to this PCE will not be measurable, and are therefore considered insignificant. Within the action area this PCE will retain its current level of function (moderately impaired).

(7) *A natural hydrograph, including peak, high, low, and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.*

The action will influence patterns of runoff, infiltration, and subsurface water exchange on a local scale, but will have no discernible effect on the size or frequency of peak, high, low or base flows, or on day-to-day or seasonal fluctuations of the natural hydrograph.

We conclude that foreseeable effects to this PCE will not be measurable, and are therefore considered insignificant. Within the action area this PCE will retain its current level of function (moderately impaired).

(8) *Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.*

The action will have temporary adverse effects to PCE #8. Construction activities completed at elevations below +2 MLLW, specifically dredge removal of contaminated sediments and placement of clean back-fill, will temporarily degrade surface water quality. The foreseeable temporary adverse effects will be limited in both physical extent and duration. Impacts to water quality will be episodic, but will persist on an intermittent basis over multiple construction seasons (2012-2015). Measurable temporary impacts will be confined to the area of the RABs between RM 2.8 and 3.6 of the lower Duwamish River.

In the long term, we expect that the action will provide measurable benefits in the form of improved sediment and water quality, and reduced contaminant exposure risks. The action will remove some of the most highly contaminated sediments found anywhere along the lower Duwamish River. The action will remove a large area and volume of contaminated sediment from one of the largest EAAs, and will contribute substantially to the comprehensive Lower Duwamish Waterway Superfund Site cleanup and remediation effort.

The action will measurably degrade water quality in the short term, but long term effects to this PCE will be beneficial. We conclude that the action will have no permanent adverse effects, and will improve long term function of PCE #8.

(9) *Sufficiently low levels of occurrence of nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass); interbreeding (e.g., brook trout); or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.*

Nonnative fish compete for prey resources within the action area. Existing baseline environmental conditions may advantage warm water fish and/or those species which have been found to exploit hardened banks and artificial overwater structure (e.g., large and smallmouth bass).

The action includes habitat enhancement and mitigation measures, including those proposed by the EPA and Applicants to satisfy NRDA requirements. These measures have been designed to improve functions which are important to and/or limiting for native salmonids. In particular, we expect that demolition of the existing overwater structures and bulkheads associated with the Boeing 2-40s Complex will remove degraded habitat which is attractive to and supports nonnative species. With inclusion of these habitat enhancement and mitigation measures, we expect that the action will provide measurable benefits in the form of modestly improved nearshore intertidal, wetland, and riparian habitat functions.

We conclude that foreseeable effects to this PCE will not be measurable, or will be beneficial, and are therefore considered insignificant. Within the action area this PCE will retain its current level of function (moderately impaired).

Indirect Effects (Bull Trout and Critical Habitat)

Indirect effects are caused by or result from the proposed action, are later in time, and are reasonably certain to occur. Indirect effects may occur outside of the area directly affected by the action (USFWS and NMFS 1998).

The proposed actions satisfy, in part, Administrative Orders on Consent agreed to by the Applicants and EPA. These Orders outline the Applicants' responsibilities under RCRA and CERCLA for cleanup and remediation of historic and continuing sources of contamination to the Lower Duwamish Waterway. The Administrative Orders on Consent do not, however, describe in total the Applicants' responsibilities under RCRA, CERCLA, and other applicable State and Federal law. Subject to a pending NRDA settlement with the Elliot Bay Natural Resource Trustees, the Jorgensen Forge and Earle M. Jorgensen Company will perform and/or construct additional habitat enhancement and mitigation measures to offset natural resource damages. Both Applicants, Jorgensen Forge and Boeing, will have continuing responsibilities for ensuring that source control measures function as expected to prevent re-contamination of the RABs. These source control measures include post-construction monitoring and adaptive management, performed in coordination with ongoing monitoring required under the applicable NPDES Stormwater General Permits.

The Administrative Orders on Consent do not prevent the Applicants from redeveloping or repurposing upland portions of the project area for uses consistent with their industrial land use designation, provided that source control measures and requirements, and all other requirements continue to be satisfied. Therefore, the Service expects that these actions may prompt, or make possible, some redevelopment of the Jorgensen Forge and Boeing facilities. We expect that this redevelopment or repurposing will be consistent with current zoning and established, light and heavy industrial uses. We assume that the EPA, Applicants, and Ecology will ensure that any future redevelopment maintains and improves upon the source controls measures implemented under this action.

Post-construction, operational discharges of stormwater runoff from redeveloped portions of the Boeing Plant 2 Facility may measurably affect surface water quality within a discernible mixing-zone. However, we expect that the proposed stormwater system improvements will also significantly reduce the discharge of conventional industrial stormwater pollutants (solids; total and dissolved metals; etc.), and nearly or completely eliminate all contributions of contaminants of concern to the RAB. The stormwater design will not cause or contribute to measurable increases in surface water temperature, degrade thermal refugia within the action area, or impair function of the proposed nearshore intertidal, wetland, and riparian enhancements.

With full and successful implementation of the agreed-upon conservation measures, including source control requirements for post-construction monitoring and adaptive management, we expect that the action's indirect effects will have an insignificant effect on bull trout and their habitat.

We conclude that this action will have no foreseeable adverse effects occurring later in time.

Effects of Interrelated & Interdependent Actions (Bull Trout and Critical Habitat)

Interrelated actions are defined as actions "that are part of a larger action and depend on the larger action for their justification"; interdependent actions are defined as actions "that have no independent utility apart from the action under consideration" (50 CFR section 402.02).

The EPA has completed a RI of the larger Lower Duwamish Waterway Superfund Site (Windward Environmental 2010), and has determined that each of the proposed actions is fundamental to, and must proceed in advance of, the comprehensive cleanup and remediation action. These actions at Jorgensen Forge and EAA-4, and at Boeing Plant 2 and DSOA, will improve sediment and water quality conditions in these portions of the lower Duwamish, will reduce long term contaminant exposure risks, and contribute substantially to the future, comprehensive Superfund Site cleanup and remediation effort. That future comprehensive cleanup and remediation action will require separate consultation pursuant to section 7 of the Act, and therefore the potential effects of that future action are not addressed here.

All wastes and contaminated media produced in completing the actions at Jorgensen Forge and EAA-4, and at Boeing Plant 2 and DSOA, will be handled, stored, transported, tested, treated, and disposed in full compliance with all applicable State and Federal requirements. Creosote-treated wood and contaminated sediments and soil will be disposed at permitted and approved upland disposal sites accepting hazardous (Subtitle C) or non-hazardous (Subtitle D) solid wastes, as appropriate. Operations at these permitted and approved upland disposal sites, and any potential effects resulting from their operations, are not a focus of this Opinion.

Subject to a pending NRDA settlement between the Responsible Party (Jorgensen Forge and Earle M. Jorgensen Company) and the Elliot Bay Natural Resource Trustees, we expect that Jorgensen Forge will implement habitat enhancement and mitigation measures to offset natural resource damages (Anchor QEA 2011a, p. 18). The EPA is not a party to the NRDA settlement. Jorgensen Forge will provide the Service with additional information as related decisions are made and design details become available.

We conclude that there are no interrelated or interdependent actions with potential effects to listed species, which the EPA, Applicants, and the Service can and should address at this time. The Service expects no foreseeable adverse effects attributable to interrelated or interdependent actions.

CUMULATIVE EFFECTS (Bull Trout and Critical Habitat)

Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Act.

Future actions with particular relevance for the action area include additional planned cleanup and remedial actions to address contaminated soil, surface water, groundwater, and sediment contamination throughout the lower Duwamish River and contributing uplands. The EPA expects that additional actions will be on-going for years into the future. Some may be Federally-funded or permitted and will require consultation, but others may not.

This Opinion has described a variety of contaminant exposures and resulting effects to bull trout, their habitat, and prey base (see *Effects of the Action*, *Acute Exposure to Hazardous Contaminants*, *Chronic Contaminant Exposures and Effects*). However, the exposures and effects described here are not unique to this action. It is reasonable to expect that future cleanup and remedial actions conducted along the lower Duwamish will present the risk of similar short term exposures and adverse effects to bull trout and designated bull trout critical habitat. However, we expect that the cumulative effect of these actions over time will be largely or exclusively beneficial.

Future actions to cleanup the Duwamish River's surface waters and sediment will improve the quality and function of FMO habitat in the action area. At the scale of the action area, we expect these actions will address an important limiting factor on normal bull trout reproduction, growth, and survival. These actions will improve long term conditions for bull trout and their prey, will address to some degree existing impediments to free movement and function of the migratory corridor, and will allow one or more PCEs of designated bull trout critical habitat to become more functional within the action area.

The lower Duwamish River floodplain is today very heavily developed. It is unlikely that future development within the action area will further degrade floodplain, riparian, or instream conditions. Instead, we expect that redevelopment according to current environmental standards may over time result in modest improvements to these conditions. Several parties have plans that include riparian and instream enhancements. As part of the larger effort to cleanup the Lower Duwamish Waterway, such actions will help to restore proper ecosystem function.

Taken as a whole, the foreseeable future State, tribal, local, and private actions will have both beneficial effects and adverse effects to bull trout and designated bull trout critical habitat. However, the Service expects that the cumulative effect of these actions over time will be largely beneficial. At the scale of the action area, we expect that future actions will improve the quality and function of FMO habitat and address important limiting factors on normal bull trout reproduction, growth, and survival.

Climate Change

There is now widespread consensus within the scientific community that atmospheric temperatures on earth are increasing and that effects from climate change will continue for at least the next several decades (IPCC 2007, pp. 2, 7-9). There is also consensus within the scientific community that this warming trend will alter current weather patterns and climatic phenomena, including the timing and intensity of extreme events such as heat waves, floods, storms, and wet-dry cycles.

Recent observations and modeling for Pacific Northwest aquatic habitats suggest that bull trout and other salmonid populations will be negatively affected by ongoing and future climate change. Rieman and McIntyre (1993, p. 8) listed several studies which predicted substantial declines of salmonid stocks in some regions related to long term climate change. More recently, Battin et al. (2007, pp. 6721-6722) modeled impacts to salmon in the Snohomish River Basin related to predictions of climate change. They suggest that long term climate impacts on hydrology would be greatest in the highest elevation basins, although site specific landscape characteristics would determine the magnitude and timing of effects. Streams fed by snowmelt and rain-on-snow events may be particularly vulnerable to the effects of climate change (Battin et al. 2007, p. 6724). Warming air temperatures are predicted to result in receding glaciers, which in time would be expected to seasonally impact turbidity levels, timing and volume of flows, stream temperatures, and species response. Changing climatic conditions are expected to similarly affect other North Puget Sound basins.

With the impacts of climate change, habitat connectivity and thermal refugia may become even more important to the growth and survival of fluvial and anadromous bull trout. If the current climate change models and predictions for Pacific Northwest aquatic habitats are accurate, bull trout may be affected by the following:

- Changes in distribution, reduced spawning habitat, and/or seasonal thermal barriers along migratory corridors resulting from increased stream temperatures.

- Short or long term changes in habitat and prey species availability due to larger or more frequent stochastic events.

- Shifts in seasonal availability of prey, resulting from changes in flow and the timing of out-migration.

CONCLUSION

The Service has identified the following recovery objectives, which are important to ensuring the long term persistence of self-sustaining, complex, and interacting groups of bull trout (USFWS 2004, p. 15): 1) maintain the current distribution of bull trout and restore distribution in previously occupied areas, 2) maintain stable or increasing trends in abundance of bull trout, 3) restore and maintain suitable habitat conditions for all bull trout life history stages and strategies, and 4) conserve genetic diversity and provide opportunities for genetic exchange.

We have reviewed the current status of the bull trout in its coterminous range, the current status of designated bull trout critical habitat in its coterminous range, the environmental baseline for the action area, the direct and indirect effects of the proposed action, the effects of interrelated and interdependent actions, and the cumulative effects that are reasonably certain to occur in the action area.

It is the Service's Biological Opinion that the action, as proposed, is not likely to jeopardize the continued existence of the bull trout in its coterminous range. This determination is based on the following:

- The waters within the action area provide non-core FMO habitat for bull trout. FMO habitat is important to bull trout of the Puget Sound Management Unit for maintaining diversity of life history forms and for providing access to productive foraging areas. Anadromous adult and subadult bull trout are known to occur in the action area, and presumably originate from the local populations of the Puyallup, Snohomish-Skykomish, and Skagit River core areas. Current information, while incomplete, suggests that the Green River does not support local bull trout populations, spawning, or rearing, and suitable bull trout spawning and rearing habitats are not present in the action area or watershed. Adult and subadult bull trout may occupy these waters at any time of year, but information is not available to reliably estimate the number of bull trout that may forage, migrate, and overwinter in the action area.

- The proposed action incorporates both permanent design elements and conservation measures which will reduce effects to habitat and avoid and minimize impacts during construction. The action's temporary adverse effects are limited in both physical extent and duration. No measurable, adverse, long term effects to bull trout, their habitat, or prey resources are anticipated, and the direct and indirect effects of the proposed action (permanent and temporary) will not preclude bull trout from foraging, migrating, and overwintering within the action area.

- The proposed action will adversely affect foraging and migrating adult and subadult bull trout. Temporary adverse effects will result from exposure to elevated levels of turbidity, re-suspended river sediments contaminated with PCBs, VOCs, dioxins/furans, and metals, and to elevated water column concentrations of these same hazardous contaminants. The action will also have temporary adverse effects on the condition and function of the migratory corridor, and to bull trout prey resources.

- The proposed action will permanently remove, in total, approximately 270,000 cy of contaminated media (sediment and soils) from more than 16.5 acres of the lower Duwamish River and adjacent uplands. The action will improve sediment and water quality conditions in these portions of the lower Duwamish, will reduce long term contaminant exposure risks with ecological benefits, and contribute to the comprehensive Lower Duwamish Waterway Superfund Site cleanup and remediation effort. The action will measurably reduce the extent and severity of chronic contaminant exposures. The Service expects no measurable, adverse, long term or permanent effects to bull trout, their habitat, or prey resources.

- With full implementation of the conservation measures, the Service expects only low numbers of adult and subadult bull trout will be exposed to construction activities and may suffer adverse effects. Impacts to water quality and resulting exposures will be temporary and episodic, but will persist on an intermittent basis over multiple construction seasons (2012-2015). Temporary exposures causing a significant disruption to normal bull trout behaviors (i.e., ability to successfully feed, move, or shelter), or potentially resulting in sublethal effects with significance for growth and long term survival, will be confined to the area of the RABs between RM 2.8 and 3.6 of the lower Duwamish River; approximately 1.5 acres (Jorgensen Forge and EAA-4) and 15 acres (Boeing Plant 2 and DSOA) of the lower Duwamish.

- Some bull trout may avoid the ongoing, sediment-generating activity, and resulting degraded water quality conditions. Degraded water quality conditions may impede or discourage free movement through the area, may prevent individuals from exploiting preferred habitats, and/or expose individuals to less favorable conditions. Use of the area may be precluded, on an intermittent basis, until water quality conditions improve. We expect that most of these exposures will elicit mild behavioral responses, and very few bull trout will suffer effects causing reduced growth, reproductive fitness (fecundity), or survival. Temporary impacts to water quality are unlikely to span the entire channel, will occupy only a portion of the channel cross-section and RABs at any one time, and will not preclude use of the migratory corridor.

- Some bull trout may experience reduced growth, reproductive fitness (fecundity), or survival as a result of sublethal contaminant exposures. Available information does not allow us to predict how exposures within the action area might add incrementally to the accumulative effect of multiple exposures over the lives of individual fish. However, over the long term and for a very small number of adult and subadult bull trout, we expect that acute exposures resulting from the proposed action will result in an incremental reduction in growth and/or reproductive fitness. Because these subadult and adult bull trout originate from any of three bull trout core areas (Puyallup, Snohomish-Skykomish, and/or Skagit River core areas), and fifteen (or more) local populations, we expect that any resulting effects to bull trout numbers (abundance) or reproduction (productivity) will not be measurable at the scale of the local populations or core areas.

- The proposed action will measurably reduce benthic prey abundance and productivity for a duration of one to two years. However, we expect that benthic organisms will rapidly recolonize and recruit to the clean back-fill, and that there will be little or no noticeable change to community composition and long term productivity. Given the limited size and duration of these temporary effects, we conclude that the action will not significantly reduce bull trout foraging opportunities or success within the action area, and therefore will not significantly disrupt bull trout foraging behaviors. In the long term, we expect that the action will provide measurable benefits in the form of a healthier prey base with reduced contaminant burdens.

- The anticipated direct and indirect effects of the action, combined with the effects of interrelated and interdependent actions, and the cumulative effects associated with future State, tribal, local, and private actions will not appreciably reduce the likelihood of survival and recovery of the species. The anticipated direct and indirect effects of the action (permanent and temporary) will not measurably reduce bull trout numbers, reproduction, or distribution at the scale of the local populations, core areas, or Puget Sound interim recovery unit. The anticipated direct and indirect effects of the action will not alter the status of bull trout at the scale of the Puget Sound interim recovery unit or coterminous range.

It is our Biological Opinion that the action, as proposed, will not destroy or adversely modify designated bull trout critical habitat. This determination is based on the following:

- The action area includes the RABs between RM 2.8 and 3.6 of the lower Duwamish River, but also extends a distance of approximately 5 miles downstream to the point where the river enters Elliot Bay. These portions of the lower Duwamish River provide eight of the nine PCEs of designated bull trout critical habitat. Suitable bull trout spawning habitats are not present in the action area; PCE #6 (suitable spawning substrates) is not present, and will not be affected.

- The action area provide non-core FMO habitat for bull trout. FMO habitat is important to bull trout of the Puget Sound Management Unit for maintaining diversity of life history forms and for providing access to productive foraging areas. Adult and subadult bull trout may occupy these waters at any time of year, but information is not available to reliably estimate the number of bull trout that forage, migrate, and overwinter in the action area.

- The proposed action incorporates both permanent design elements and conservation measures which will reduce effects to habitat and avoid and minimize impacts during construction. The action's temporary adverse effects are limited in both physical extent and duration. No measurable, adverse, long term effects to designated bull trout critical habitat are anticipated, and the direct and indirect effects of the proposed action (permanent and temporary) will not preclude bull trout from foraging, migrating, and overwintering within the action area.

- The proposed action will have measurable, temporary adverse effects to PCEs #2 (migration habitats with minimal impediments), #3 (bull trout prey base), and # 8 (water quality and quantity). Any permanent or temporary effects to the other PCEs will not be measurable, or will be beneficial, and are therefore considered insignificant.

- Construction activities, specifically dredge removal of contaminated sediments and placement of clean back-fill, will temporarily degrade surface water quality and function of the migratory corridor. Temporary adverse effects will be limited in both physical extent and duration; these effects will be confined to the area of the RABs between RM 2.8 and 3.6 of the lower Duwamish River, but will persist on an intermittent basis over multiple construction seasons (2012-2015). The action will measurably diminish function of the migratory corridor in the short term, but in the long term the foreseeable effects to PCE #2 will not be measurable, or will be beneficial, and are therefore considered insignificant. The action will not create or contribute to any permanent physical, biological, or water quality impediments to migration or free movement.

- The action will provide measurable benefits in the long term, in the form of improved sediment and water quality, and reduced chronic contaminant exposure risks. The action will measurably degrade water quality in the short term, but in the long term the foreseeable effects to PCE #8 will not be measurable, or will be beneficial, and are therefore considered insignificant. We conclude that the action will have no permanent adverse effects, and will improve the long term function of PCE #8 (water quantity and quality).

- The action will have temporary adverse effects to the bull trout prey base. Temporary adverse effects will be limited in both physical extent and duration; these effects will be confined to the area of the RABs between RM 2.8 and 3.6 of the lower Duwamish River. Dredging and placement of back-fill will measurably reduce benthic prey abundance and productivity within the RABs for a duration of one to two years. However, we expect that benthic organisms will rapidly recolonize and recruit to the clean back-fill, and that there will be little or no noticeable change to community composition and long term productivity within the RABs. In the long term, we expect that the action will provide measurable benefits in the form of improved sediment and water quality, reduced contaminant exposure risks, and a healthier prey base with reduced contaminant burdens.

- Within the action area, the PCEs of designated bull trout critical habitat will remain functional, and designated critical habitat will continue to serve its conservation role as FMO. The anticipated direct and indirect effects of the action, combined with the effects of interrelated and interdependent actions, and the cumulative effects associated with future State, tribal, local, and private actions will not prevent the PCEs of critical habitat from being maintained, and will not degrade the current ability to establish functioning

- PCEs at the scale of the action area. Critical habitat within the action area will continue to serve the intended conservation role for the species at the scale of the core area, interim recovery unit, and coterminous range.

INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is defined by the Service as an act which actually kills or injures wildlife. Such act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavior patterns, including breeding, feeding, or sheltering (50 CFR 17.3). Harass is defined by the Service as an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering (50 CFR 17.3). Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are non-discretionary, and must be undertaken by the EPA so that they become binding conditions of any grant or permit issued, as appropriate, for the exemption in section 7(o)(2) to apply. The EPA has a continuing duty to regulate the activity covered by this incidental take statement. If the EPA (1) fails to assume and implement the terms and conditions or (2) fails to require the contractor or applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the EPA must report the progress of the action and its impact on the species to the Service as specified in the incidental take statement [50 CFR section 402.14(i)(3)].

AMOUNT OR EXTENT OF TAKE

We anticipate that take in the form of harm and harassment of adult and subadult bull trout from the Puyallup, Snohomish-Skykomish, and Skagit River core areas will result from the proposed action.

The Service expects that incidental take of bull trout will be difficult to detect or quantify for the following reasons: 1) the low likelihood of finding dead or injured individuals; 2) delayed mortality; and, 3) losses may be masked by seasonal fluctuations in numbers. Where this is the case, we use a description of the affected habitat (i.e., physical extent, frequency, and duration), and the intensity of temporary exposures, as a surrogate indicator of take.

1. Incidental take of bull trout in the form of harm resulting from degraded surface water quality during construction, exposure to elevated turbidity and sedimentation, and acute contaminant exposures. Water quality will be degraded intermittently during the approximately 450-day period when construction activities are being completed below +2 MLLW of the lower Duwamish River. Take will result when levels of turbidity reach or exceed the following:

i) When background NTU levels are exceeded by 160 NTUs at any point in time; or

ii) When background NTU levels are exceeded by 59 NTUs for more than 1 hour, continuously, over a 12-hour workday; or

iii) When background NTU levels are exceeded by 18 NTUs for more than 7 hours, cumulatively, over a 12-hour workday; or

iv) When background NTU levels are exceeded by 9.5 NTUs for the duration of an entire workday, or longer.

- All adult and subadult bull trout within the wetted perimeter of the lower Duwamish River, from a point approximately 800 ft upstream, to a point approximately 800 ft downstream of the ongoing, sediment-generating activity (an area of approximately 16.5 acres in total), will be harmed between August 1, 2012 and February 15, 2015 (Jorgensen Forge Facility and EAA-4: August 1, 2013 to February 15, 2014; Boeing Plant 2 Facility and DSOA: August 1, 2012 to February 15, 2015).

EFFECT OF THE TAKE

In the accompanying Opinion, the Service has determined that the level of anticipated take is not likely to result in jeopardy to the bull trout.

REASONABLE AND PRUDENT MEASURES

The proposed action incorporates design elements and conservation measures which we expect will reduce permanent effects to habitat and avoid and minimize impacts during construction. We expect that the EPA will fully implement these measures, and therefore they have not been specifically identified as Reasonable and Prudent Measures or Terms and Conditions.

The following reasonable and prudent measures (RPMs) are necessary and appropriate to minimize the impact of incidental take to bull trout:

1. Minimize and monitor incidental take caused by elevated turbidity and sedimentation during construction.

2. Minimize and monitor incidental take caused by acute contaminant exposures during construction.

TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the Act, the EPA must comply with the following terms and conditions, which implement the RPMs described above. These terms and conditions are non-discretionary.

The following terms and conditions are required for the implementation of RPM 1:

1. The EPA and Applicants (Jorgensen Forge and Boeing) shall monitor turbidity levels in the lower Duwamish River during sediment-generating activities, when conducting work below +2 MLLW.

2. The EPA and Applicants shall monitor for compliance with State of Washington aquatic life turbidity criteria: less than 10 NTU over background; or, less than 20 percent over background, when background turbidities exceed 50 NTU.

3. Monitoring shall be conducted at a distance of 150 ft upstream and/or downstream of sediment-generating activities, dependent on position within the tide-cycle. To the extent practicable, samples shall be taken from directly upstream/downstream of the on-going activity, or activities, at two depths (near-surface and near-bottom).

4. The EPA and Applicants will implement a two-tiered water quality monitoring plan that includes both intensive and routine monitoring:

    a. Dredge Operations Below +2 MLLW – (1) Intensive monitoring will be conducted during the first 7 days of dredging each construction season and shall include a minimum of 2 sample events per day. (2) Routine monitoring will be conducted 2 days per week when not conducting intensive monitoring, and shall include a minimum of 2 sample events per day. (3) If monitoring documents an apparent exceedance of the turbidity criteria, a second sample shall be taken as confirmation. If a second sample confirms the exceedance, additional sampling for conventional parameters will be conducted every 2 hours for the remainder of the workday, or until compliance with the criteria has been documented. (4) If there is a change in equipment (e.g., dredge bucket type) additional monitoring will be conducted.

    b. Placement of Backfill Below +2 MLLW – (1) Intensive monitoring will be conducted during the first 7 days each construction season and shall include a minimum of 2 sample events per day. (2) If monitoring documents an apparent exceedance of the turbidity criteria, a second sample shall be taken as confirmation. If a second sample confirms the exceedance, additional sampling for conventional parameters will be conducted every 2 hours for the remainder of the workday, or until compliance with the criteria has been documented. (3) If intensive monitoring consistently documents compliance with criteria, no routine monitoring is required. (4) If there is a change in equipment or methods additional monitoring will be conducted.

5. If, at any time, turbidity measured at a distance of 150 ft exceeds 59 NTUs over background, the EPA and Applicants shall conduct additional monitoring to confirm that measured turbidity at a distance of 800 ft does not exceed 18 NTUs over background. Monitoring at a distance of 800 ft will be conducted every 2 hours for the remainder of the workday, or until measured turbidity falls below 18 NTUs over background.

6. If turbidity levels measured at 800 ft from the sediment-generating activities exceed 160 NTUs above background at any time, 59 NTUs above background for more than 1 hour continuously, or 18 NTUs above background for more than 7 hours, cumulatively, over a 12-hour workday, then the amount of take authorized by the Incidental Take Statement will have been exceeded. Sediment-generating activities shall cease, and the EPA shall contact the Federal Activities Branch at the Washington Fish and Wildlife Office in Lacey, Washington (360-753-9440) within 24 hours.

7. Monitoring shall be conducted to establish background turbidity levels away from the influence of sediment-generating activities. Background turbidity shall be monitored at least twice daily during sediment-generating activities. In the event of a visually appreciable change in background turbidity, an additional sample shall be taken. Alternatively, the EPA and Applicants may choose to implement continuous monitoring with a deployable data logger instrument.

8. If, in cooperation with other permit authorities, the EPA and Applicants develop a functionally equivalent monitoring strategy, they may submit this plan to the Service for review and approval in lieu of the above monitoring requirements. The strategy must be submitted to the Service a minimum of 60 days prior to construction. In order to be approved for use in lieu of the above requirements, the plan must meet each of the same objectives.

9. The EPA shall submit a monitoring report to the Washington Fish and Wildlife Office in Lacey, Washington (Attn: Federal Activities Branch), by April 1 following each construction season. The report shall include, at a minimum, the following: (a) dates, times, and locations of construction activities, (b) monitoring results, sample times, locations, and measured turbidities (in NTUs), (c) summary of construction activities and measured turbidities associated with those activities, and (d) summary of corrective actions taken to reduce turbidity.

The following terms and conditions are required for the implementation of RPM 2:

1. The EPA and Applicants (Jorgensen Forge and Boeing) shall monitor turbidity levels in the lower Duwamish River, per the Terms and Conditions implementing RPM 1 (above).

2. The EPA and Applicants shall provide a copy of the approved spill control and containment plan(s) to the Service prior to any operations generating a contaminated, or potentially contaminated, waste stream (i.e., soils, sediments, or water).

3. Protocols for waste sampling and characterization shall strictly adhere to Quality Assurance/ Quality Control standards, so as to ensure that contaminated and uncontaminated waste streams are accurately characterized, to prevent co-mingling of contaminated and uncontaminated waste streams, and to inform selection of appropriate treatment and disposal methods.

4. The EPA and Applicants shall provide and maintain on-site the materials and equipment necessary to ensure at all times there is sufficient capacity for the temporary storage, proper segregation, treatment, and ultimate dispensation of generated wastes, including water in-contact with contaminated or potentially contaminated sediments or soils.

5. The EPA and Applicants shall detain and treat all dredge return water to ensure compliance with the State of Washington's surface water quality standards within 800 ft of the point(s) of discharge. All points of discharge shall be located within the limits of the RABs.

6. The EPA and Applicants shall implement a two-tiered water quality monitoring plan designed to ensure proper function of the dredge return water treatment system(s) for the duration of construction activities: (a) Intensive monitoring will be conducted during the first 7 days of dredging each construction season; (b) Intensive monitoring shall include at least two 24-hour composite samples analyzed for PCBs and metals, and continuous turbidity monitoring (every 15 minutes); (c) Routine monitoring will be conducted 2 days per week when not conducting intensive monitoring, and shall include 24-hour composite samples analyzed for turbidity; (d) If monitoring documents an apparent exceedance of applicable water quality criteria, discharge from the dredge return water treatment system(s) will be temporarily suspended; and, (e) The EPA and Applicants will inspect the dredge return water treatment system(s) for proper function, and will perform required maintenance and/or replacement of system components (e.g., geotextile fabric tubes, flocculent injection system, carbon adsorption vessels).

7. The EPA and Applicants shall ensure that all equipment used to handle contaminated waste streams, including containment and transport BMPs, storage containers, and temporary on-site treatment facilities or BMPs, is properly decontaminated prior to handling any uncontaminated waste stream.

8. The EPA shall document waste handling, containment, testing, storage, treatment, and disposal operations according to all applicable State and Federal requirements. The EPA shall submit a monitoring report to the Washington Fish and Wildlife Office in Lacey, Washington (Attn: Federal Activities Branch), by April 1 following each construction season. The report shall include, at a minimum, the following: (a) a description of the treatment facilities and/or BMPs utilized on-site; (b) a quantitative waste characterization

or profile for any sediments and water disposed at an in-water dredged material disposal site(s), and for any return water discharged within the RABs; and (c) a summary of corrective actions taken to maintain and/or reestablish proper function of the dredge return water treatment system(s).

We expect that the amount or extent of incidental take described above will not be exceeded as a result of the proposed action. The RPMs, with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. If, during the course of the action, this level of incidental take is exceeded, such incidental take represents new information requiring reinitiation of consultation and review of the reasonable and prudent measures provided. The EPA must provide an explanation of the causes of the taking and review with the Service the need for possible modification of the reasonable and prudent measures.

The Service is to be notified within three working days upon locating a dead, injured or sick endangered or threatened species specimen. Initial notification must be made to the nearest U.S. Fish and Wildlife Service Law Enforcement Office. Notification must include the date, time, precise location of the injured animal or carcass, and any other pertinent information. Care should be taken in handling sick or injured specimens to preserve biological materials in the best possible state for later analysis of cause of death, if that occurs. In conjunction with the care of sick or injured endangered or threatened species or preservation of biological materials from a dead animal, the finder has the responsibility to ensure that evidence associated with the specimen is not unnecessarily disturbed. Contact the U.S. Fish and Wildlife Service Law Enforcement Office at (425) 883-8122, or the Service's Washington Fish and Wildlife Office at (360) 753-9440.

REINITIATION NOTICE

This concludes formal consultation on the action outlined in the request. As provided in 50 CFR section 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

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APPENDICES

Appendix A: Status of the Species (Bull Trout; Coterminous Range)

Appendix B: Status of Designated Critical Habitat (Bull Trout; Coterminous Range)

Appendix C: Core Area Summaries – Puyallup, Snohomish-Skykomish, and Skagit River Core Areas (Bull Trout)

Appendix D: Sediment Analysis Framework (2010)

APPENDIX A: Status of the Species (Bull Trout; Coterminous Range)

Appendix A: Status of the Species (Bull Trout)

Listing Status

The coterminous United States population of the bull trout (*Salvelinus confluentus*) was listed as threatened on November 1, 1999 (64 FR 58910). The threatened bull trout generally occurs in the Klamath River Basin of south-central Oregon; the Jarbidge River in Nevada; the Willamette River Basin in Oregon; Pacific Coast drainages of Washington, including Puget Sound; major rivers in Idaho, Oregon, Washington, and Montana, within the Columbia River Basin; and the St. Mary-Belly River, east of the Continental Divide in northwestern Montana (Bond 1992, p. 2; Brewin and Brewin 1997, p. 215; Cavender 1978, pp. 165-166; Leary and Allendorf 1997, pp. 716-719).

Throughout its range, the bull trout are threatened by the combined effects of habitat degradation, fragmentation, and alterations associated with dewatering, road construction and maintenance, mining, grazing, the blockage of migratory corridors by dams or other diversion structures, poor water quality, entrainment (a process by which aquatic organisms are pulled through a diversion or other device) into diversion channels, and introduced non-native species (64 FR 58910). Although all salmonids are likely to be affected by climate change, bull trout are especially vulnerable given that spawning and rearing are constrained by their location in upper watersheds and the requirement for cold water temperatures (Battin et al. 2007, pp. 6672-6673; Rieman et al. 2007, p. 1552). Poaching and incidental mortality of bull trout during other targeted fisheries are additional threats.

The bull trout was initially listed as three separate Distinct Population Segments (DPSs) (63 FR 31647; 64 FR 17110). The preamble to the final listing rule for the United States coterminous population of the bull trout discusses the consolidation of these DPSs with the Columbia and Klamath population segments into one listed taxon and the application of the jeopardy standard under section 7 of the Act relative to this species (64 FR 58910):

> Although this rule consolidates the five bull trout DPSs into one listed taxon, based on conformance with the DPS policy for purposes of consultation under section 7 of the Act, we intend to retain recognition of each DPS in light of available scientific information relating to their uniqueness and significance. Under this approach, these DPSs will be treated as interim recovery units with respect to application of the jeopardy standard until an approved recovery plan is developed. Formal establishment of bull trout recovery units will occur during the recovery planning process.

Current Status and Conservation Needs

In recognition of available scientific information relating to their uniqueness and significance, five segments of the coterminous United States population of the bull trout are considered essential to the survival and recovery of this species and are identified as interim recovery units: 1) Jarbidge River, 2) Klamath River, 3) Columbia River, 4) Coastal-Puget Sound, and 5) St. Mary-Belly River (USFWS 2002a, pp. iv, 2, 7, 98; 2004a, Vol. 1 & 2, p. 1; 2004b, p. 1). Each of these interim recovery units is necessary to maintain the bull trout's distribution, as well as its genetic and phenotypic diversity, all of which are important to ensure the species' resilience to changing environmental conditions.

A summary of the current status and conservation needs of the bull trout within these interim recovery units is provided below and a comprehensive discussion is found in the Service's draft recovery plans for the bull trout (USFWS 2002a, pp. vi-viii; 2004a, Vol. 2 p. iii-x; 2004b, pp. iii-xii).

The conservation needs of bull trout are often generally expressed as the four "Cs": cold, clean, complex, and connected habitat. Cold stream temperatures, clean water quality that is relatively free of sediment and contaminants, complex channel characteristics (including abundant large wood and undercut banks), and large patches of such habitat that are well connected by unobstructed migratory pathways are all needed to promote conservation of bull trout at multiple scales ranging from the coterminous to local populations (a local population is a group of bull trout that spawn within a particular stream or portion of a stream system). The recovery planning process for bull trout (USFWS 2002a, pp. 49-50; 2004a, Vol 1 & 2 pp. 12-18; 2004b, pp. 60-86) has also identified the following conservation needs: 1) maintenance and restoration of multiple, interconnected populations in diverse habitats across the range of each interim recovery unit, 2) preservation of the diversity of life-history strategies, 3) maintenance of genetic and phenotypic diversity across the range of each interim recovery unit, and 4) establishment of a positive population trend. Recently, it has also been recognized that bull trout populations need to be protected from catastrophic fires across the range of each interim recovery unit (Rieman et al. 2003).

Central to the survival and recovery of bull trout is the maintenance of viable core areas (USFWS 2002a, pp. 53-54; 2004a, Vol. 1 pp. 210-218, Vol 2. pp. 61-62; 2004b, pp. 15-30, 64-67). A core area is defined as a geographic area occupied by one or more local bull trout populations that overlap in their use of rearing, foraging, migratory, and overwintering habitat. Each of the interim recovery units listed above consists of one or more core areas. There are 121 core areas recognized across the coterminous range of the bull trout (USFWS 2002a, pp. 6, 48, 98; 2004a, Vol. 1 p. vi, Vol. 2 pp. 14, 134; 2004b, pp. iv, 2; 2005, p. ii).

Jarbidge River Interim Recovery Unit

This interim recovery unit currently contains a single core area with six local populations. Less than 500 resident and migratory adult bull trout, representing about 50 to 125 spawning adults, are estimated to occur in the core area. The current condition of the bull trout in this interim recovery unit is attributed to the effects of livestock grazing, roads, incidental mortalities of released bull trout from recreational angling, historic angler harvest, timber harvest, and the introduction of non-native fishes (USFWS 2004b). The draft bull trout recovery plan (USFWS 2004b) identifies the following conservation needs for this interim recovery unit: 1) maintain the current distribution of the bull trout within the core area, 2) maintain stable or increasing trends in abundance of both resident and migratory bull trout in the core area, 3) restore and maintain suitable habitat conditions for all life history stages and forms, and 4) conserve genetic diversity and increase natural opportunities for genetic exchange between resident and migratory forms of the bull trout. An estimated 270 to 1,000 spawning bull trout per year are needed to provide for the persistence and viability of the core area and to support both resident and migratory adult bull trout (USFWS 2004b).

Klamath River Interim Recovery Unit

This interim recovery unit currently contains three core areas and seven local populations. The current abundance, distribution, and range of the bull trout in the Klamath River Basin are greatly reduced from historical levels due to habitat loss and degradation caused by reduced water quality, timber harvest, livestock grazing, water diversions, roads, and the introduction of non-native fishes (USFWS 2002a). Bull trout populations in this interim recovery unit face a high risk of extirpation (USFWS 2002a). The draft Klamath River bull trout recovery plan (USFWS 2002a) identifies the following conservation needs for this interim recovery unit: 1) maintain the current distribution of bull trout and restore distribution in previously occupied areas, 2) maintain stable or increasing trends in bull trout abundance, 3) restore and maintain suitable habitat conditions for all life history stages and strategies, 4) conserve genetic diversity and provide the opportunity for genetic exchange among appropriate core area populations. Eight to 15 new local populations and an increase in population size from about 2,400 adults currently to 8,250 adults are needed to provide for the persistence and viability of the three core areas (USFWS 2002a).

Columbia River Interim Recovery Unit

The Columbia River interim recovery unit includes bull trout residing in portions of Oregon, Washington, Idaho, and Montana. Bull trout are estimated to have occupied about 60 percent of the Columbia River Basin, and presently occur in 45 percent of the estimated historical range (Quigley and Arbelbide 1997, p. 1177). This interim recovery unit currently contains 97 core areas and 527 local populations. About 65 percent of these core areas and local populations occur in central Idaho and northwestern Montana. The Columbia River interim recovery unit has declined in overall range and numbers of fish (63 FR 31647). Although some strongholds still exist with migratory fish present, bull trout generally occur as isolated local populations in headwater lakes or tributaries where the migratory life history form has been lost. Though still widespread, there have been numerous local extirpations reported throughout the Columbia River basin. In Idaho, for example, bull trout have been extirpated from 119 reaches in 28 streams (IDFG, in litt. 1995). The draft Columbia River bull trout recovery plan (USFWS 2002c) identifies the following conservation needs for this interim recovery unit: 1) maintain or expand the current distribution of the bull trout within core areas, 2) maintain stable or increasing trends in bull trout abundance, 3) restore and maintain suitable habitat conditions for all bull trout life history stages and strategies, and 4) conserve genetic diversity and provide opportunities for genetic exchange.

This interim recovery unit currently contains 97 core areas and 527 local populations. About 65 percent of these core areas and local populations occur in Idaho and northwestern Montana. The condition of the bull trout within these core areas varies from poor to good. All core areas have been subject to the combined effects of habitat degradation and fragmentation caused by the following activities: dewatering; road construction and maintenance; mining; grazing; the blockage of migratory corridors by dams or other diversion structures; poor water quality; incidental angler harvest; entrainment into diversion channels; and introduced non-native species. The Service completed a core area conservation assessment for the 5-year status review and determined that, of the 97 core areas in this interim recovery unit, 38 are at high risk of extirpation, 35 are at risk, 20 are at potential risk, 2 are at low risk, and 2 are at unknown risk (USFWS 2005, pp. 2, Map A, and pp. 73-83).

Coastal-Puget Sound Interim Recovery Unit

Bull trout in the Coastal-Puget Sound interim recovery unit exhibit anadromous, adfluvial, fluvial, and resident life history patterns. The anadromous life history form is unique to this interim recovery unit. This interim recovery unit currently contains 14 core areas and 67 local populations (USFWS 2004a). Bull trout are distributed throughout most of the large rivers and associated tributary systems within this interim recovery unit. Bull trout continue to be present in nearly all major watersheds where they likely occurred historically, although local extirpations have occurred throughout this interim recovery unit. Many remaining populations are isolated or fragmented and abundance has declined, especially in the southeastern portion of the interim recovery unit. The current condition of the bull trout in this interim recovery unit is attributed to the adverse effects of dams, forest management practices (e.g., timber harvest and associated road building activities), agricultural practices (e.g., diking, water control structures, draining of wetlands, channelization, and the removal of riparian vegetation), livestock grazing, roads, mining, urbanization, poaching, incidental mortality from other targeted fisheries, and the introduction of non-native species. The draft Coastal-Puget Sound bull trout recovery plan (USFWS 2004a) identifies the following conservation needs for this interim recovery unit: 1) maintain or expand the current distribution of bull trout within existing core areas, 2) increase bull trout abundance to about 16,500 adults across all core areas, and 3) maintain or increase connectivity between local populations within each core area.

St. Mary-Belly River Interim Recovery Unit

This interim recovery unit currently contains six core areas and nine local populations (USFWS 2002b). Currently, bull trout are widely distributed in the St. Mary-Belly River drainage and occur in nearly all of the waters that it inhabited historically. Bull trout are found only in a 1.2-mile reach of the North Fork Belly River within the United States. Redd count surveys of the North Fork Belly River documented an increase from 27 redds in 1995 to 119 redds in 1999. This increase was attributed primarily to protection from angler harvest (USFWS 2002b). The current condition of the bull trout in this interim recovery unit is primarily attributed to the effects of dams, water diversions, roads, mining, and the introduction of non-native fishes (USFWS 2002b). The draft St. Mary-Belly River bull trout recovery plan (USFWS 2002b) identifies the following conservation needs for this interim recovery unit: 1) maintain the current distribution of the bull trout and restore distribution in previously occupied areas, 2) maintain stable or increasing trends in bull trout abundance, 3) restore and maintain suitable habitat conditions for all life history stages and forms, 4) conserve genetic diversity and provide the opportunity for genetic exchange, and 5) establish good working relations with Canadian interests because local bull trout populations in this interim recovery unit are comprised mostly of migratory fish, whose habitat is mostly in Canada.

Life History

Bull trout exhibit both resident and migratory life history strategies. Both resident and migratory forms may be found together, and either form may produce offspring exhibiting either resident or migratory behavior (Rieman and McIntyre 1993, pp. 1-18) . Resident bull trout complete their entire life cycle in the tributary (or nearby) streams in which they spawn and rear. The resident form tends to be smaller than the migratory form at maturity and also produces fewer eggs (Fraley and Shepard 1989, p. 1; Goetz 1989, pp. 15-16). Migratory bull trout spawn in tributary streams where juvenile fish rear 1 to 4 years before migrating to either a lake (adfluvial form), river (fluvial form) (Fraley and Shepard 1989, pp. 135-137; Goetz 1989, pp. 22-25), or saltwater (anadromous form) to rear as subadults and to live as adults (Cavender 1978, pp. 139, 165-68; McPhail and Baxter 1996, p. 14; WDFW et al. 1997, pp. 17-18, 22-26). Bull trout normally reach sexual maturity in 4 to 7 years and may live longer than 12 years. They are iteroparous (they spawn more than once in a lifetime). Repeat- and alternate-year spawning has been reported, although repeat-spawning frequency and post-spawning mortality are not well documented (Fraley and Shepard 1989, pp. 135-137; Leathe and Graham 1982, p. 95; Pratt 1992, p. 6; Rieman and McIntyre 1996, p. 133).

The iteroparous reproductive strategy of bull trout has important repercussions for the management of this species. Bull trout require passage both upstream and downstream, not only for repeat spawning but also for foraging. Most fish ladders, however, were designed specifically for anadromous semelparous salmonids (fishes that spawn once and then die, and require only one-way passage upstream). Therefore, even dams or other barriers with fish passage facilities may be a factor in isolating bull trout populations if they do not provide a downstream passage route. Additionally, in some core areas, bull trout that migrate to marine waters must pass both upstream and downstream through areas with net fisheries at river mouths. This can increase the likelihood of mortality to bull trout during these spawning and foraging migrations.

Growth varies depending upon life-history strategy. Resident adults range from 6 to 12 inches total length, and migratory adults commonly reach 24 inches or more (Goetz 1989, pp. 29-32; Pratt 1984, p. 13) The largest verified bull trout is a 32-pound specimen caught in Lake Pend Oreille, Idaho, in 1949 (Simpson and Wallace 1982).

Habitat Characteristics

Bull trout have more specific habitat requirements than most other salmonids (Rieman and McIntyre 1993, p. 7). Habitat components that influence bull trout distribution and abundance include water temperature, cover, channel form and stability, valley form, spawning and rearing substrate, and migratory corridors (Fraley and Shepard 1989, pp. 137, 141; Goetz 1989, pp. 19-26; Bond in Hoelscher and Bjornn 1989, p. 57; Howell and Buchanan 1992, p. 1; Pratt 1992, p. 6; Rich 1996, pp. 35-38; Rieman and McIntyre 1993, pp. 4-7; Rieman and McIntyre 1995, pp. 293-294; Sedell and Everest 1991, p. 1; Watson and Hillman 1997, pp. 246-250). Watson and Hillman (1997, pp. 247-249) concluded that watersheds must have specific physical characteristics to provide the habitat requirements necessary for bull trout to successfully spawn and rear and that these specific characteristics are not necessarily present throughout these watersheds. Because bull trout exhibit a patchy distribution, even in pristine habitats (Rieman and McIntyre 1993, p. 7), bull trout should not be expected to simultaneously occupy all available habitats (Rieman et al. 1997, p. 1560).

Migratory corridors link seasonal habitats for all bull trout life histories. The ability to migrate is important to the persistence of bull trout (Gilpin, in litt. 1997, pp. 4-5; Rieman and McIntyre 1993, p. 7; Rieman et al. 1997, p. 1114). Migrations facilitate gene flow among local populations when individuals from different local populations interbreed or stray to nonnatal streams. Local populations that are extirpated by catastrophic events may also become reestablished by bull trout migrants. However, it is important to note that the genetic structuring of bull trout indicates there is limited gene flow among bull trout populations, which may encourage local adaptation within individual populations, and that reestablishment of extirpated populations may take a long time (Rieman and McIntyre 1993, p. 7; Spruell et al. 1999, pp. 118-120). Migration also allows bull trout to access more abundant or larger prey, which facilitates growth and reproduction. Additional benefits of migration and its relationship to foraging are discussed below under "Diet."

Cold water temperatures play an important role in determining bull trout habitat quality, as these fish are primarily found in colder streams (below 15 °C or 59 °F), and spawning habitats are generally characterized by temperatures that drop below 9 °C (48 °F) in the fall (Fraley and Shepard 1989, p. 133; Pratt 1992, p. 6; Rieman and McIntyre 1993, p. 7).

Thermal requirements for bull trout appear to differ at different life stages. Spawning areas are often associated with cold-water springs, groundwater infiltration, and the coldest streams in a given watershed (Baxter et al. 1997, pp. 426-427; Pratt 1992, p. 6; Rieman and McIntyre 1993, p. 7; Rieman et al. 1997, p. 1117). Optimum incubation temperatures for bull trout eggs range from 2 °C to 6 °C (35 °F to 39 °F) whereas optimum water temperatures for rearing range from about 6 °C to 10 °C (46 °F to 50 °F) (Buchanan and Gregory 1997, pp. 121-122; Goetz 1989, pp. 22-24; McPhail and Murray 1979, pp. 41, 50, 53, 55). In Granite Creek, Idaho, Bonneau and Scarnecchia (1996) observed that juvenile bull trout selected the coldest water available in a plunge pool, 8 °C to 9 °C (46 °F to 48 °F), within a temperature gradient of 8 °C to 15 °C (4 °F to 60 °F). In a landscape study relating bull trout distribution to maximum water temperatures, Dunham et al. (2003) found that the probability of juvenile bull trout occurrence does not become high (i.e., greater than 0.75) until maximum temperatures decline to 11 °C to 12 °C (52 °F to 54 °F).

Although bull trout are found primarily in cold streams, occasionally these fish are found in larger, warmer river systems throughout the Columbia River basin (Buchanan and Gregory 1997, pp. 121-122; Fraley and Shepard 1989, pp. 135-137; Rieman and McIntyre 1993, p. 2; Rieman and McIntyre 1995, p. 288; Rieman et al. 1997, p. 1114). Availability and proximity of cold water patches and food productivity can influence bull trout ability to survive in warmer rivers (Myrick et al. 2002). For example, in a study in the Little Lost River of Idaho where bull trout were found at temperatures ranging from 8 °C to 20 °C (46 °F to 68 °F), most sites that had high densities of bull trout were in areas where primary productivity in streams had increased following a fire (Bart Gamett, pers. comm. 2002).

All life history stages of bull trout are associated with complex forms of cover, including large woody debris, undercut banks, boulders, and pools (Fraley and Shepard 1989, pp. 135-137; Goetz 1989, pp. 22-25; Hoelscher and Bjornn 1989, p. 54; Pratt 1992, p. 6; Rich 1996, pp. 35-38; Sedell and Everest 1991, p. 1; Sexauer and James 1997, pp. 367-369; Thomas 1992, pp. 4-5; Watson and Hillman 1997, pp. 247-249). Maintaining bull trout habitat requires stability of stream channels and maintenance of natural flow patterns (Rieman and McIntyre 1993, p. 7). Juvenile and adult bull trout frequently inhabit side channels, stream margins, and pools with suitable cover (Sexauer and James 1997, pp. 367-369). These areas are sensitive to activities that directly or indirectly affect stream channel stability and alter natural flow patterns. For example, altered stream flow in the fall may disrupt bull trout during the spawning period, and channel instability may decrease survival of eggs and young juveniles in the gravel from winter through spring (Fraley and Shepard 1989, pp. 135-137; Pratt 1992, p. 6; Pratt and Huston 1993, pp. 70-72). Pratt (1992, p. 6) indicated that increases in fine sediment reduce egg survival and emergence.

Bull trout typically spawn from August through November during periods of increasing flows and decreasing water temperatures. Preferred spawning habitat consists of low-gradient stream reaches with loose, clean gravel (Fraley and Shepard 1989, p. 135). Redds are often constructed in stream reaches fed by springs or near other sources of cold groundwater (Goetz 1989, p. 15; Pratt 1992, p. 8; Rieman and McIntyre 1996, p. 133). Depending on water temperature, incubation is normally 100 to 145 days (Pratt 1992, p. 8). After hatching, fry remain in the substrate, and time from egg deposition to emergence may surpass 200 days. Fry normally emerge from early April through May, depending on water temperatures and increasing stream flows (Ratliff and Howell 1992 in Howell and Buchanan 1992, pp. 10, 15; Pratt 1992, pp. 5-6).

Early life stages of fish, specifically the developing embryo, require the highest inter-gravel dissolved oxygen (IGDO) levels, and are the most sensitive life stage to reduced oxygen levels. The oxygen demand of embryos depends on temperature and on stage of development, with the greatest IGDO required just prior to hatching.

A literature review conducted by the Washington Department of Ecology (WDOE 2002) indicates that adverse effects of lower oxygen concentrations on embryo survival are magnified as temperatures increase above optimal (for incubation). In a laboratory study conducted in Canada, researchers found that low oxygen levels retarded embryonic development in bull trout (Giles and Van der Zweep 1996, pp. 54-55). Normal oxygen levels seen in rivers used by bull trout during spawning ranged from 8 to 12 mg/L (in the gravel), with corresponding instream levels of 10 to 11.5 mg/L (Stewart et al. 2007). In addition, IGDO concentrations, water velocities in the water column, and especially the intergravel flow rate, are interrelated variables that affect the survival of incubating embryos (ODEQ 1995). Due to a long incubation period of 220+ days, bull trout are particularly sensitive to adequate IGDO levels. An IGDO level below 8 mg/L is likely to result in mortality of eggs, embryos, and fry.

Migratory forms of bull trout may develop when habitat conditions allow movement between spawning and rearing streams and larger rivers, lakes or nearshore marine habitat where foraging opportunities may be enhanced (Brenkman and Corbett 2005, pp. 1073, 1079-1080; Frissell 1993, p. 350; Goetz et al. 2004, pp. 45, 55, 60, 68, 77, 113-114, 123, 125-126). For example, multiple life history forms (e.g., resident and fluvial) and multiple migration patterns have been noted in the Grande Ronde River (Baxter 2002). Parts of this river system have retained habitat conditions that allow free movement between spawning and rearing areas and the mainstem Snake River. Such multiple life history strategies help to maintain the stability and persistence of bull trout populations to environmental changes. Benefits to migratory bull trout include greater growth in the more productive waters of larger streams, lakes, and marine waters; greater fecundity resulting in increased reproductive potential; and dispersing the population across space and time so that spawning streams may be recolonized should local populations suffer a catastrophic loss (Frissell 1999, pp. 15-16; MBTSG 1998, pp. iv, 48-50; Rieman and McIntyre 1993, pp. 18-19; USFWS 2004a, Vol. 2, p. 63). In the absence of the migratory bull trout life form, isolated populations cannot be replenished when disturbances make local habitats temporarily unsuitable. Therefore, the range of the species is diminished, and the potential for a greater reproductive contribution from larger fish with higher fecundity is lost (Rieman and McIntyre 1993, pp. 1-18).

Diet

Bull trout are opportunistic feeders, with food habits primarily a function of size and life-history strategy. A single optimal foraging strategy is not necessarily a consistent feature in the life of a fish, because this strategy can change as the fish progresses from one life stage to another (i.e., juvenile to subadult). Fish growth depends on the quantity and quality of food that is eaten (Gerking 1994), and as fish grow, their foraging strategy changes as their food changes, in quantity, size, or other characteristics. Resident and juvenile migratory bull trout prey on terrestrial and aquatic insects, macrozooplankton, and small fish (Boag 1987, p. 58; Donald and Alger 1993, pp. 239-243; Goetz 1989, pp. 33-34). Subadult and adult migratory bull trout feed on various fish species (Brown 1994, p. 21; Donald and Alger 1993, p. 242; Fraley and Shepard 1989, p. 135; Leathe and Graham 1982, p. 95). Bull trout of all sizes other than fry have been found to eat fish up to half their length (Beauchamp and VanTassell 2001). In nearshore marine areas of western Washington, bull trout feed on Pacific herring (*Clupea pallasi*), Pacific sand lance (*Ammodytes hexapterus*), and surf smelt (*Hypomesus pretiosus*) (Goetz et al. 2004, p. 114; WDFW et al. 1997, p. 23).

Bull trout migration and life history strategies are closely related to their feeding and foraging strategies. Migration allows bull trout to access optimal foraging areas and exploit a wider variety of prey resources. Optimal foraging theory can be used to describe strategies fish use to choose between alternative sources of food by weighing the benefits and costs of capturing one source of food over another. For example, prey often occur in concentrated patches of abundance ("patch model" ; (Gerking 1994). As the predator feeds in one patch, the prey population is reduced, and it becomes more profitable for the predator to seek a new patch rather than continue feeding on the original one. This can be explained in terms of balancing energy acquired versus energy expended. For example, in the Skagit River system, anadromous bull trout make migrations as long as 121 miles between marine foraging areas in Puget Sound and headwater spawning grounds, foraging on salmon eggs and juvenile salmon along their migration route (WDFW et al. 1997). Anadromous bull trout also use marine waters as migration corridors to reach seasonal habitats in non-natal watersheds to forage and possibly overwinter (Brenkman and Corbett 2005, p. 1079; Goetz et al. 2004, pp. 36, 60).

Changes in Status of the Coastal-Puget Sound Interim Recovery Unit

Although the status of bull trout in Coastal-Puget Sound interim recovery unit has been improved by certain actions, it continues to be degraded by other actions, and it is likely that the overall status of the bull trout in this population segment has not improved since its listing on November 1, 1999. Improvement has occurred largely through changes in fishing regulations and habitat-restoration projects. Fishing regulations enacted in 1994 either eliminated harvest of bull trout or restricted the amount of harvest allowed, and this likely has had a positive influence on the abundance of bull trout. Improvement in habitat has occurred following restoration projects intended to benefit either bull trout or salmon, although monitoring the effectiveness of these projects seldom occurs. On the other hand, the status of this population segment has been adversely affected by a number of Federal and non-Federal actions, some of which were addressed under section 7 of the Act. Most of these actions degraded the environmental baseline; all of those addressed through formal consultation under section 7 of the Act permitted the incidental take of bull trout.

Section 10(a)(1)(B) permits have been issued for Habitat Conservation Plans (HCP) completed in the Coastal-Puget Sound population segment. These include: 1) the City of Seattle's Cedar River Watershed HCP, 2) Simpson Timber HCP (now Green Diamond Resources), 3) Tacoma Public Utilities Green River HCP, 4) Plum Creek Cascades HCP, 5) Washington State Department of Natural Resources (WSDNR) State Trust Lands HCP, 6) West Fork Timber HCP, and 7) WSDNR Forest Practices HCP. These HCPs provide landscape-scale conservation for fish, including bull trout. Many of the covered activities associated with these HCPs will contribute to conserving bull trout over the long-term; however, some covered activities will result in short-term degradation of the baseline. All HCPs permit the incidental take of bull trout.

Changes in Status of the Columbia River Interim Recovery Unit

The overall status of the Columbia River interim recovery unit has not changed appreciably since its listing on June 10, 1998. Populations of bull trout and their habitat in this area have been affected by a number of actions addressed under section 7 of the Act. Most of these actions resulted in degradation of the environmental baseline of bull trout habitat, and all permitted or analyzed the potential for incidental take of bull trout. The Plum Creek Cascades HCP, Plum Creek Native Fish HCP, Storedahl Daybreak Mine HCP, and WSDNR Forest Practices HCP addressed portions of the Columbia River population segment of bull trout.

Changes in Status of the Klamath River Interim Recovery Unit

Improvements in the Threemile, Sun, and Long Creek local populations have occurred through efforts to remove or reduce competition and hybridization with non-native salmonids, changes in fishing regulations, and habitat-restoration projects. Population status in the remaining local populations (Boulder-Dixon, Deming, Brownsworth, and Leonard Creeks) remains relatively unchanged. Grazing within bull trout watersheds throughout the recovery unit has been curtailed. Efforts at removal of non-native species of salmonids appear to have stabilized the Threemile and positively influenced the Sun Creek local populations. The results of similar efforts in Long Creek are inconclusive. Mark and recapture studies of bull trout in Long Creek indicate a larger migratory component than previously expected.

Although the status of specific local populations has been slightly improved by recovery actions, the overall status of Klamath River bull trout continues to be depressed. Factors considered threats to bull trout in the Klamath Basin at the time of listing – habitat loss and degradation caused by reduced water quality, past and present land use management practices, water diversions, roads, and non-native fishes – continue to be threats today.

Changes in Status of the Saint Mary-Belly River Interim Recovery Unit

The overall status of bull trout in the Saint Mary-Belly River interim recovery unit has not changed appreciably since its listing on November 1, 1999. Extensive research efforts have been conducted since listing, to better quantify populations of bull trout and their movement patterns. Limited efforts in the way of active recovery actions have occurred. Habitat occurs mostly on Federal and Tribal lands (Glacier National Park and the Blackfeet Nation). Known problems due to instream flow depletion, entrainment, and fish passage barriers resulting from operations of the U.S. Bureau of Reclamation's Milk River Irrigation Project (which transfers Saint Mary-Belly River water to the Missouri River Basin) and similar projects downstream in Canada constitute the primary threats to bull trout and to date they have not been adequately addressed under section 7 of the Act. Plans to upgrade the aging irrigation delivery system are being pursued, which has potential to mitigate some of these concerns but also the potential to intensify dewatering. A major fire in August 2006 severely burned the forested habitat in Red Eagle and Divide Creeks, potentially affecting three of nine local populations and degrading the baseline.

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